AUTOMATION

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AUGUST 1955

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THE MAGAZINE OF AUTOMATIC OPERATIONS

WEAN "AUTOMATED" TRANS-CAR LINE SOLVES HEAVY PARTS HANDLING PROBLEM

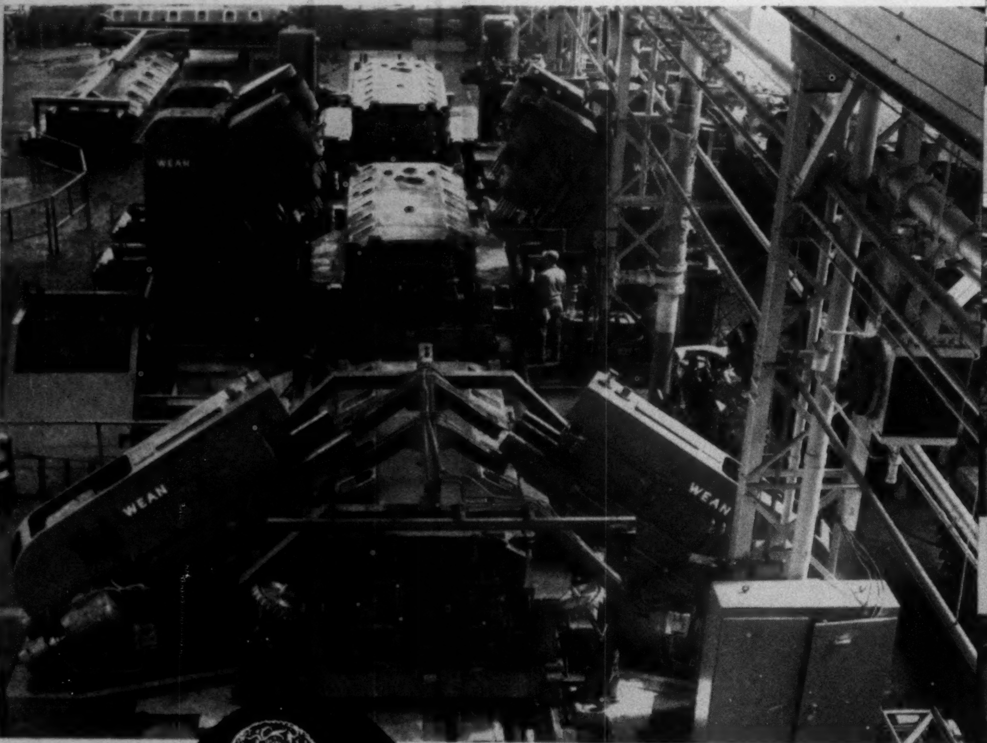
Unique system carries bulky sections through entire machining operation

The Massey-Harris Co. is used to handling and precision working large machine components. Thus, when they accepted the contract to produce combat vehicle hulls for the Army they immediately got in touch with Wean Equipment engineers.

A team of Wean Equipment engineers working with a similar group from Massey-Harris soon vetoed the possibility of using standard machine tools on a cost basis. It was decided a complete line, especially built to do the job, was the only practical answer.

In eight months' time, Wean Equipment developed and built the now famous trans-car line. The line is composed of three stations: milling, drilling, and boring. The unusual feature is the car that operates on a set of tracks, running between stations, and eliminates all handling of the bulky, heavy hull.

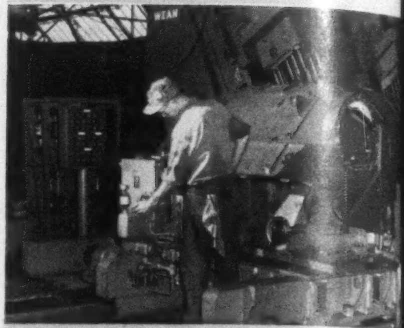
If special "automated" machinery is what you're looking for, call in a Wean Equipment man today. He represents probably the widest experience in specialized machinery to be found anywhere. Like Massey-Harris, you'll find Wean the surest, most inexpensive way to soundly engineered, result-getting machinery.



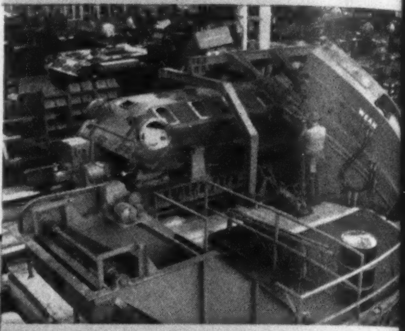
Over-all view of Wean Line that effected tremendous savings in producing giant hulls.

Wean

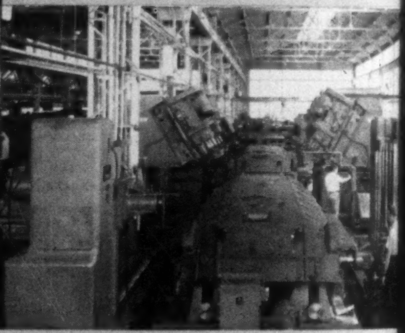
EQUIPMENT CORPORATION
CLEVELAND, OHIO



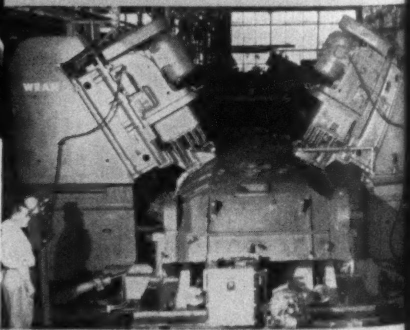
Unique trans-car that carries hull fron
station to station.



Milling operation. Dry cutting wit
carbide cutters. Air jets remove chips



Drilling operation. Beneath the floor a
coolant system with magnetic chip
separator.



Boring operation. Drills, taps an
reamers are of high speed steel. Al
operations are automatic.

AUGUST, 1955
Vol. 2—No. 8

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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automation outlook

LET THEM KNOW—AND QUICK

". . . we had a dream the other night. And in the dream got to talking with a fellow named Whitney. You remember Whitney . . . Eli Whitney. He invented the cotton gin and put thousands of people out of work and nearly wrecked our whole economy. Then steam power got into our factories and finished the job. 'You look mighty prosperous for a man who's been out of a job about 150 years', Eli remarked to us. 'The last time I was around, the whole country was on the way to the poor house.'

'Oh, things turned out o.k. after all,' we told him. 'Your cotton gin and then steam power and a lot of other Industrial Revolution gadgets kept turning out more and better products at a lower price. Then we had to hire more people to keep up with the demand. We never had it so good.

'That's not what I've been hearing lately,' Whitney retorted. 'Only now they're talking about something called automation. Is that a new name for the cotton gin?'

'Something like that,' we explained. 'Automation's just a word somebody made up to mean different machines that do a lot of office and factory jobs faster and better.'

'Sounds just like old times,' Eli said, beginning to fade off into nothing. 'But I'll tell you one thing . . . You'd better explain this new Industrial Revolution better than we did the last one, or there's going to be a lot of people worrying and resisting just because they don't know what it's all about. You've got to let them know that there'll be more jobs and more money and shorter hours and more products that people can afford to buy. And you'd better be quick about it.'

And then we woke up. But Eli Whitney's last words lingered on: 'You've got to let them know . . . and be quick.' Let who know—and what—and how. The *who* is easy. It's everybody. First there are the workers. Then there are the heads of business and shareholders and the consuming public. All of these people have a stake in automation. The *how* we realized is a positive public relations program to disabuse all the who's of the misconceptions they've picked up. Any company that has present or future plans to automate its offices or plant has an obligation to tell its various 'publics' how they will be affected.

That *what* necessarily will vary in detail from company to company, but the overall pattern falls along these lines:

1. New techniques are essential if *production is to keep pace with demand.* We'll have 20 per cent more people in 10 years, but our working population will go up only six per cent.
2. New techniques *permit plant expansion* that would be physically or economically impossible with old-fashioned methods. John Plain & Company, world's largest wholesale mail order house, found that out when it substituted electronic accounting equipment for pencil and adding machine. Business increased 300 per cent in five years, an increase that would have been impossible without faster ways of keeping accounts, billing and accumulating inventory control data. The added capacity enabled the company among other things to set up a new Special Gifts Division to supply industry with gifts and premiums.
3. As business expands, *more people will be needed* to operate and service new equipment. They will have less drudgery, their skills will be upgraded, pay will be higher and working hours shorter.
4. Fast, efficient production methods *hold prices down.* Automobiles, radios and television sets are just three examples of products that would be beyond the reach of the mass market without modern techniques.
5. The consumer will get *faster, better service,* with John Plain's new methods, shipments go out in less than three hours after orders are received; previously the time lag was frequently as much as two weeks.

We have a feeling that Eli Whitney will be watching Industrial Revolution Part II to give us a nudge now and then if we start repeating Part I's mistakes. . .—*Public Relations Board Newsletter.*

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BPA

With the new LeBlond-Carlstedt Rapid Borer, you can bore, trepan or counterbore holes *3 to 8 times faster than by the conventional D-bit method!* We'll prove this at the Machine Tool Show. You'll see a 1⅛" hole bored in solid Stainless 303 at better than 7" per minute. We'll bore 4140, C-1141 and 6150 even faster!

The Rapid Borer was developed expressly to accommodate revolutionary new tooling which cuts at very high speed with excellent accuracy and finish. Cutting oil is forced between the boring bar and hole wall forming a continuous bearing. It flushes back through a hole in the boring head and bar, carrying away the chips as it goes. Chip form is controlled both by tool angles and proper feed and speed combinations; thus tool faces are kept clean and chip passage clear. Cutter design produces balanced cutting pressures thereby controlling concentricity.

This new tooling requires a machine with the following characteristics all of which are incorporated in the Rapid Borer's design:

High spindle horsepower

Ample rigidity throughout

Complete absence of vibration at all speeds

Infinitely-variable feeds (up to 38" per minute), independent of speeds, while running under load

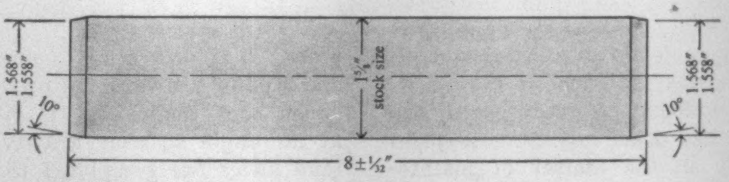
Final drive to spindle through belts

Large volume of cutting oil

Basically, the Rapid Borer is suited to work that is symmetrical for balance in rotation – round, square, octagonal, tapered or stepped. A wide variety of hole diameters and depths as well as work sizes can be accommodated.

Tell us about the holes you'd like to produce faster. Large holes or small. If the Rapid Borer can handle the job, we'll show you how to produce them faster than ever before.

Like to see your own materials bored at the show?



Just prepare sample bars of the materials you are now boring, or intend to bore. Make them according to the drawing here. Bring them to the Show and we'll bore them for you on the Rapid Borer.

THE
MACHINE TOOL
SHOW
CHICAGO ILL.
SEPT. 6-17 1955

See it at the show. No. 1313 — dead center of the new exhibition hall.

. . . cut with confidence

The R.K.LeBlond Machine Tool Company

Cincinnati 8, Ohio

World's largest builder of a complete line of lathes for more than 68 years

LeBLOND
of Cincinnati

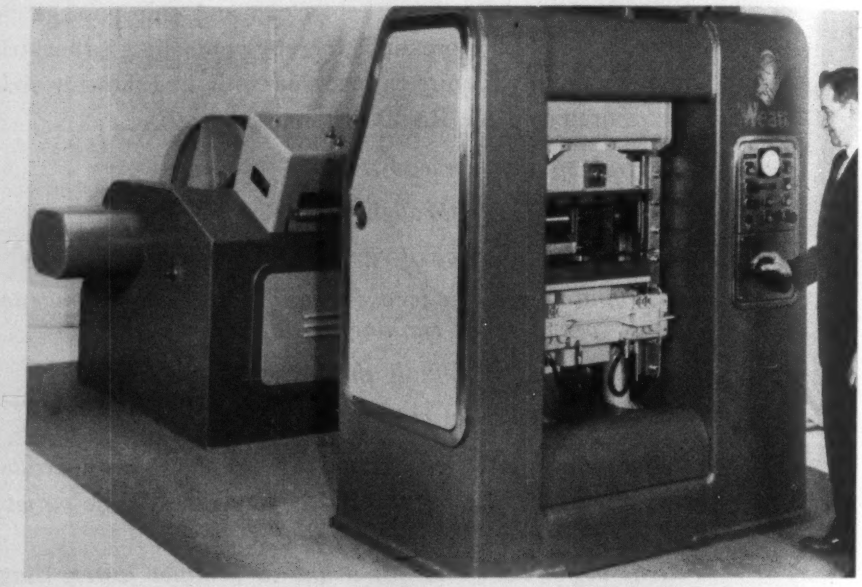
AUTOMATION news

Today's events and developments in the field of automation

Flying Press— Stamping on the Run

NEW CONCEPT of press design with greater operating speed as its objective has been utilized by the Wean Equipment Corp. in developing a new press which is now ready for marketing. To appreciate the new press it is important to review existing practices. A conventional press most frequently works in conjunction with a coil of steel which is fed into the press intermittently by a device called a press feeder. The coiled steel comes to a full stop in the die and the upper die then strikes the metal and performs the work. When the upper die is withdrawn, the completed part falls through the lower die, the feeder starts again and indexes another measured length and stops, awaiting the upper die to make the second part. The speed range of such equipment, even in medium size presses, seldom reaches 250 strokes per minute.

The Wean flying press eliminates the necessity for starting and stopping the feed of the coiled steel. In the new press this moves at a continuous speed through the press at all times, and the upper and lower dies move forward and synchronize with this speed during the time in which the stamping is performed, thereby greatly increasing the number of parts that can be made each minute. The production here will reach as high as 600-900 strokes per minute. The idea of dies which move with the strip as the work is being done is not new in itself, but the method by which it is accomplished is entirely new, and embodies the idea in a completely successful and vibrationless machine.


PROTOTYPE of flying press developed by the Wean Equipment Corp. Speed range of this 60-ton press is between 600 and 900 strokes per minute. Coiled metal feeds through the press at a continuous speed which is synchronized with forward movement of dies during the stamping operation. This press has neither conventional clutch nor brake.

In addition to great speed, the press has other advantages—principally in the matter of maintenance and downtime. A conventional press uses a clutch and brake to actuate the ram of the press, and these two units must work every time the press makes a stroke. Seventy per cent of all press maintenance is generally found in these two items. The flying press has neither clutch nor brake. It has no flywheel as such, but stores its energy in the motion of the dies and die holders, thereby applying the latent stored energy right at the place of work rather than at the end of an overhung shaft, as in the conventional press. It is interesting to note that one type of conventional press, the "open back inclinable", is pitched at an angle so that gravity will take away the completed part or the scrap by a sliding effect. As the speed of these presses is brought to its maximum, it is frequently necessary to apply a jet of air to assist the force of gravity in this removal. In this new press, because the strip never stops as the speed gets greater, the velocity of the completed part becomes greater and is ejected from the press with greater and greater ease as the speed increases. The flying press has been designed into a packaged unit, and its physical appearance is completely different from that of an ordinary press as it has been streamlined and product engineered so that it resembles a machine tool. All the controls necessary for operation have been brought to a stainless steel panel at one side of the machine. It will be built in a number of different size ranges.

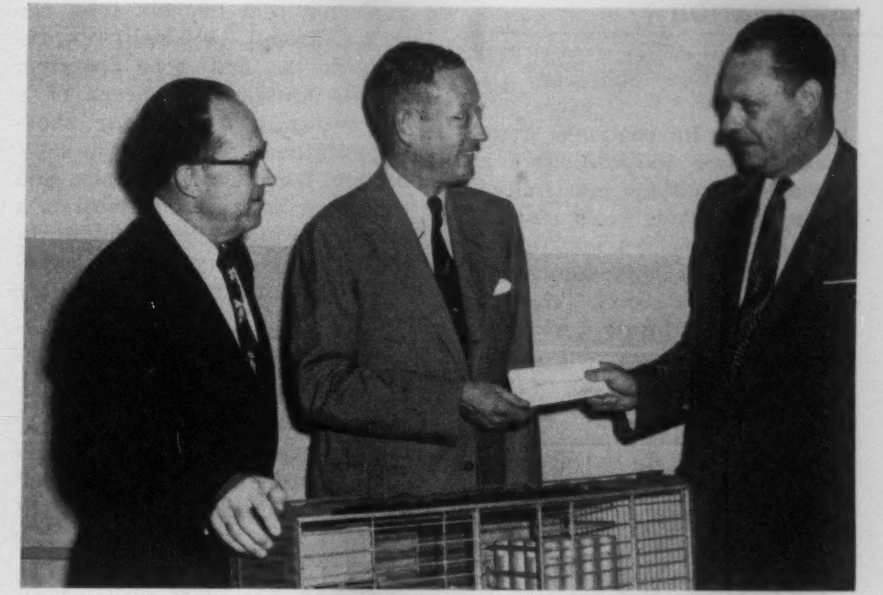
Titanium Foil Available

TITANIUM will soon be available in a thickness of 0.0005-inch, it has been announced by **Monroe Sherman**, president of the American Silver Co. The company has already successfully rolled titanium down to the thinness of 0.0008-inch in commercial quantities. In these ultrathin gages, commercially pure titanium offers new possibilities to the designer and engineer. It is only 57 per cent as heavy as alloy steel and is superior in strength to many metals, including steel and aluminum. These unique qualities have placed titanium high on the demand list in the aircraft, instrumentation, and chemical industries. American Silver Co. produces titanium foil in the commercially pure alloys, Ti-75A and RC-55. Mill limits on this material are as follows: Minimum thickness—0.0008-inch, maximum width—7¾-inch, minimum width, 3/32-inch.

APPOINTMENT of **William E. Van Horne** as assistant sales manager of Industrial Nucleonics Corp. has been announced by **Wilbert E. Chope**, president. Van Horne has been associated with Industrial Nucleonics since 1952, when he joined the firm as a sales engineer in charge of the Chicago territory. Prior to this he was with the Brown Instruments Div. of Minneapolis-Honeywell Regulator Co., also in the capacity of sales engineer.

New Company In Computer Field

FORMATION of Datamatic Corp. under joint ownership of Minneapolis-Honeywell Regulator Co. and Raytheon Mfg. Co. has been announced. Joint undertaking will engineer and market electronic data processing systems for use in business and government. Honeywell will have a 60 per cent and Raytheon a 40 per cent interest in the new corporation. In announcing the new company, **Paul B. Wishart**, Honeywell president and **Charles F. Adams, Jr.**, president of Raytheon said, "We are on the threshold of a new era in business and commerce characterized by the use of electronic data processing techniques to speed up and simplify thousands of operations which are daily becoming more complex. The Datamatic Corp. will combine the strength of both Honeywell and Raytheon in the development and exploitation of this new field. The extensive background that both organizations have in electronics makes this joint venture a logical extension of their activities."

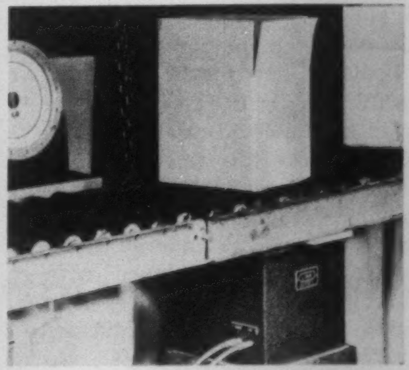


CHRYSLER CORP. has presented a $5000 check to the Wayne University Materials Management Center. E. A. Skae, president of Equipment Mfg. Inc., and chairman of the Center's finance committee (center) is shown accepting the check from Herbert O. Horning of Chrysler Corp.'s materials handling staff. Looking on is Dr. Spencer A. Larsen, director of the Center. The Materials Management Center was established at the request of industry with the objective of providing technical and management personnel an opportunity to expand knowledge of their jobs.

Memo—Be In Chicago Sept. 6-16—A Must See

UNEQUALED opportunity to investigate advancements in machine tools and production equipment is presented by the simultaneous occurrence of the National Machine Tool Show, Production Engineering Show, and Metalworking Machinery & Equipment Exposition—all to be held in Chicago, Sept. 6-16.

The Machine Tool Show will be



WEIGHING DEVICE that records the full weight of any package that may only be partially resting on the scale has been introduced by the Link Engineering Co. This allows complete and accurate centralization of control remote from the actual weighing operation. Complete accuracy in weighing can be accomplished with items literally dangling over the edges. The scale is adaptable for installation by simple mechanical attachment, and its light weight, only 50 pounds, makes it readily portable. Manufactured to suit any specification, the unit has a total capacity of 1200 pounds held in the International Amphitheatre; over 165 exhibitors are scheduled to display practically all types of machine tools manufactured. Of special interest to those concerned with automation will be many examples showing the progress made in the development of automatic operations and controls. September issue of AUTOMATION will include a preview of some of the outstanding developments which can be seen at the Machine Tool Show.

Subtitled "Automation Exhibition", the Production Engineering Show is to be held at the Navy Pier and it is expected that over 250 exhibitors will display mechanisms, instruments and equipment that contribute to more automatic operations in production and processing. It is not concerned with metalworking only, but cuts across the whole field of production including all types of manufacturing.

The Metalworking Machinery and Equipment Exposition to be held at the Coliseum rounds out the trio of shows. Scheduled for exhibition by more than 70 manufacturers are new, improved and special purpose metalworking machines.

Attendance at the shows is expected to be in excess of 100,000. As an interesting sidelight, a helicopter shuttle service will operate between the International Amphitheatre and the Navy Pier in addition to special bus service to aid the exposition visitor.

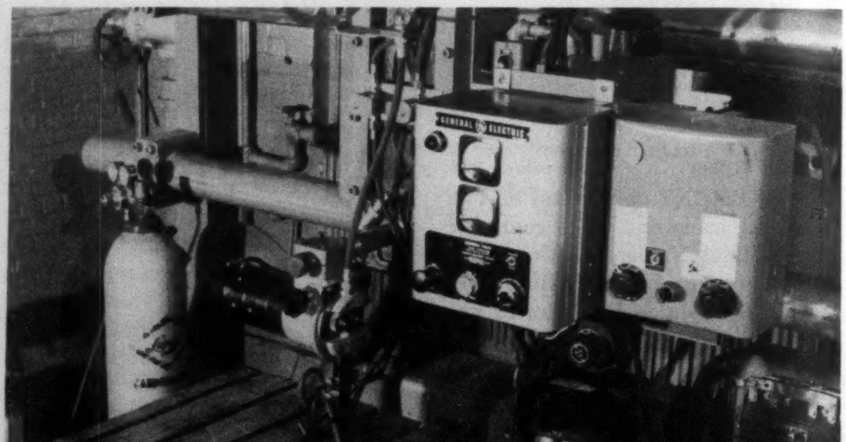
TV Bridges a Gap

CLOSED CIRCUIT television system is helping the Armstrong Cork Co. ensure top quality production of linoleum and plastic floorings. The TV setup bridges a three-story gap in the linoleum production operations. On the third floor, a workman shovels linoleum mix into a hopper. On the way downstairs the raw ingredients undergo intensive mixing, are combined with color pigments and emerge in granule form at huge calender rolls which form the mix into sheets of flooring material. It's important that the mix enter the rolls uniformly. Normally a workman at the first floor operation signals upstairs, by means of a bell system, to stop or start shoveling on the third floor. Now a TV camera focuses on the mix and the image is flashed upstairs on a receiver, which allows the workmen to keep an eye on the operation below and regulate shoveling accordingly.

MAJOR CHANGE in the organizational structure of the Sheffield Corp. has been announced by **Louis Polk,** president. Company is well known manufacturer of gages of all types, dies, taps and special machinery. Changes are designed as a means to aggressively meet changing competitive situations. Five production divisions have been formed and managers appointed who have complete responsibility for sales, service, engineering and manufacturing. General manager appointments include **Victor Boll,** Contract Services; **Jack Welch,** Machine Tool, Murchey and Cavitron; **William I. Wilt,** Standard Production Instruments; **W. Fay Aller,** Research; and **Benton D. Witemeyer,** Fixed Gages and Inspection Room Instruments.

Unique Positioning With Lines and Light

PROBLEM of positioning one object in relation to another is solved by an instrument called the fringe counter manufactured by Ferranti Ltd. The fringe counter illustrates a method by which the head of a jig boring machine can be simply and positively positioned at the table to within one ten-thousandth of an inch. It makes use of prismatic gratings, consisting of glass strips carrying a line structure with 5000 lines to the inch. When a beam of parallel light is passed through two of these gratings superimposed, the movement of one grating with respect to the other will give a modulated light pattern, which will vary through one complete cycle



CARBON DIOXIDE shielded automatic welding equipment developed by General Electric Co. includes wire-feeder, torch, control panel, reel mount and motor-generator unit. It employs extremely high wire speeds (up to 1000 inches per minute) and very short arc lengths to produce a deeply-penetrating arc with a minimum of spatter. The technique also causes violent agitation in the weld puddle, allowing more porosity-producing gas to escape. Other features of the automatic Fillerarc equipment include all-position operation—even vertical and overhead automatic welding is possible; a compact, combined operator station-control panel with two pushbuttons to control the entire welding operation; adaptability to light or heavy-gage materials; easy tack welding by opening and closing the starting circuit; and a crater-filling circuit which is available to taper wire speeds at the end of the weld.

Process monitoring and control

Chemical analysis

48 hours instead of 45 days!

Dynamic and static testing

Here's a true story of how data-handling automation can save real dollars. The data-handling system shown, right, was installed by Convair's Ft. Worth, Texas, division. In just two weeks...during a single series of pressure measurements . . . Convair saved a substantial portion *of the entire system cost!* The saving in time was even more impressive. Tabulated test data reached design engineers just 48 HOURS after the wind-tunnel tests, a striking contrast to the 45 days previously required for reducing hundreds of manometer-tube photographs.

Perhaps wind-tunnel data reduction isn't of particular interest to you. But whatever your problem, if it involves *data*, it will pay you to learn how CEC *systems engineering* can make the handling of that data more accurate, faster, less expensive. Send today for Bulletin CEC 1304-X16.

Two of four identical 50-channel units comprising system

Specifically, this is what the custom-designed Convair data-processing system does once the "start" switch is pressed . . .

- *...Automatically measures, digitizes and records output from 200 pressure pickups.*
- *...Reads out digital pressure values at a rate of 200 points in 2-minute period.*
- *...Operates at an overall system accuracy of 0.75% of full-scale pressure, including errors in transducers.*
- *...Automatically compensates for residual bridge unbalance in each of the 200 channels.*
- *...Controls calibration factor on all channels independently.*
- *...Punches out on paper tape and tabulates in numerical typewritten format the results of all 200 pressure measurements.*

CEC *Systems Division*

Consolidated Engineering Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

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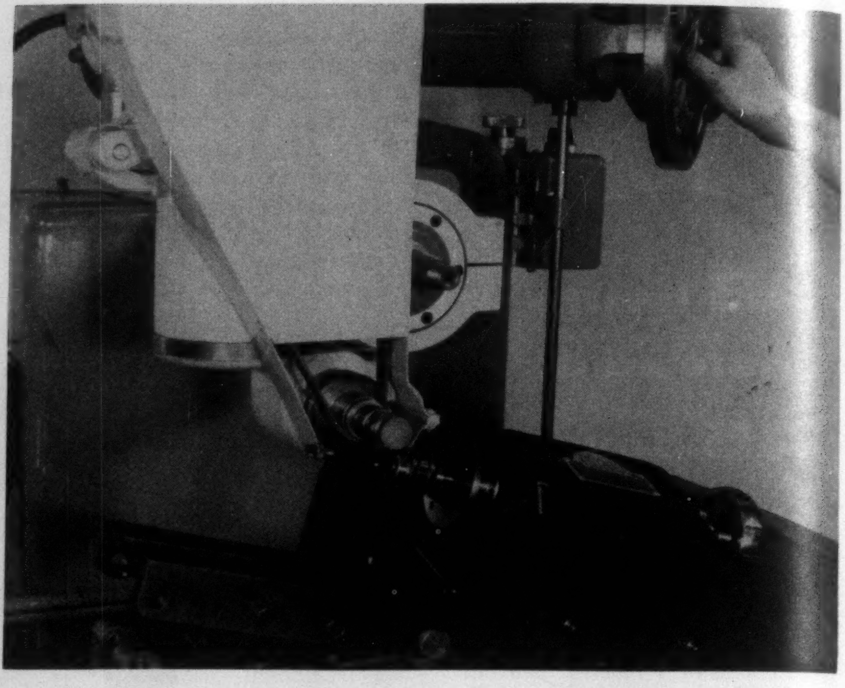
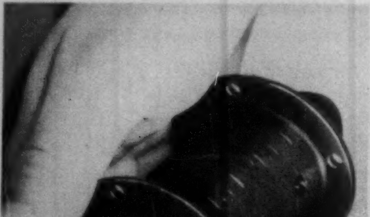


APPLICATION of the surface grinder to many other jobs than ordinary flat grinding is possible by use of attachments developed by the DoAll Co. For example, a high-speed spindle permits grinding of hard-to-reach surfaces and recesses with small wheels. Adaptation of standard grinders to automatic operation through the use of standard attachments is feasible. In some instances it is possible to achieve precision shaped parts with one machine, one setup and in one operation.

of light and darkness for a relative movement of one line width. If one grating is tilted, light and dark zones are formed which move at approximately right angles to the direction of movement of the gratings.

These facts are applied to the measurement of the movement of the machine's table. A long grating is attached to the table and two narrow beams of light are passed through this and also through a second small grating, which is stationary. Each beam is collected and passed to its individual photoelectric cell, which will show an electrical signal output every time the light is unobscured by the presence of lines. This will occur every time the table is moved one ten-thousandth of an inch. Two beams are used so that the direction of travel of the light and dark zones, and thus the direction of travel of the table, can be ascertained. An identical arrangement of gratings and photoelectric cells is used for measurement of the machine's movement in a direction perpendicular to the first. If the electrical signals from the photocells are counted as the table moves, an exact measurement of distance traveled, in multiples of one ten-thousandth of an inch, is achieved. This counting is readily accomplished, using electronic circuits.

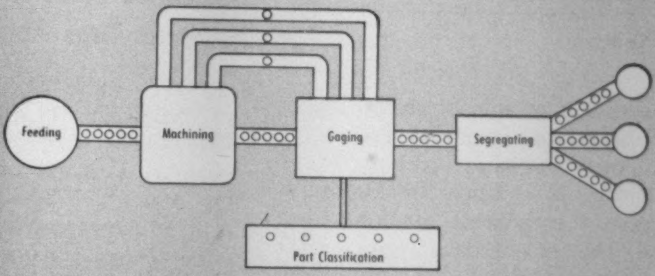
In practice, one point is defined on the work and the position of the next point is ascertained in terms of longitudinal and transverse displacements from the first point. With the electronic system, these displacements are set up by a series of knobs on a control unit, one knob for each digit of the distance, the final knob in each case reading in ten-thousandths. This operation, in fact, sets upon an electronic counter the number of signals which will be received from the photocells when the table has moved through the required distances. The machine table is moved, both longitudinally and transversely, by electric motors. When the movement is initiated, the motors start to run in the correct direction and the signals received from the photocells start to cancel the counts set up on the control unit. When the count in each case reaches zero, the motor stops and the work is correctly positioned for the boring operation.



ADVANCED design axial flow blowers which provide highly efficient air delivery or exhaust have been announced by the Pesco Products Div. of the Borg-Warner Corp. Pesco will manufacture the blowers under license from an English firm. The "baby" of the line is a miniaturized 1⅜ inch diameter blower which weighs eight ounces and delivers 16 cfm at a pressure of 0.75 inches of water. The tiny Pesco motor which fits inside this assembly is less than one inch in diameter. Other standard production units will vary up to six inches in diameter and will be available as single or multistage blowers. Larger units are planned for future production.

NEW GENERAL MANAGER of Wagner Brothers Equipment Co. has been appointed by **J. R. Wagner**, president. **Steve Jerome** who takes over the position has had several decades of widely diversified experience on the engineering, production and management levels of plant operation. Of his new post, Jerome states, "My primary objective at the Equipment Co. will be to translate the latest de-

AUTOMATION DEMANDS RELIABLE CONTROLS



Dimensional control is the very heart of automation for the metalworking industry. Consequently, care in the selection of In-Process and Post-Process control devices is very important.

As a long recognized leader in air, electric and electronic gaging, Sheffield is prepared to furnish either:

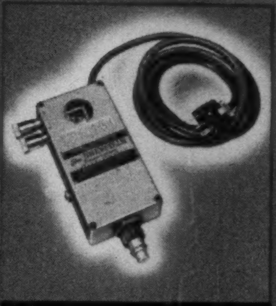
- Packaged controls and tooling ready to install
- Complete automation gaging and transfer systems ready to operate

FUNCTIONS and ADVANTAGES

- Determine minute dimensional variations, rapidly and with repetitive precision
- Initiate warning signals
- Actuate control mechanisms
- Segregate acceptable, oversize and undersize parts
- Accurately classify parts by sizes
- Accommodate almost limitless range of tolerances
- Operate with interchangeable tooling
- Are small, compact and easily mounted
- Have unusually long, trouble-free service life
- Are easily interchanged

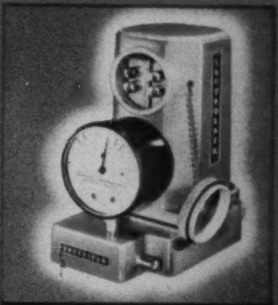
7125

Shown here are a few of those Sheffield control units so widely used in automated systems.



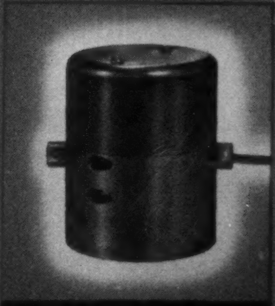
AIRLECTRIC

A limit type pneumatic control to actuate signals and relays.



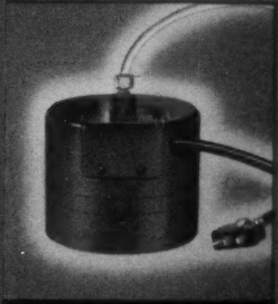
LECTROLAIR

A sealed-in control to actuate signals and relays and also to give visual size indication.



DIFFERENTIAL

A gage head for checking taper, hole parallelism or hole center distance and converting the result into an actuating electrical impulse.



VARIATION

A pneumatic gage head for external or internal dimensions and face to axis runout—converts the result into an actuating electrical impulse.

See us at the Machine Tool Show, Booth 1305

For more detailed information, write for Bulletin AU-1154

The Sheffield Corporation
Division 500
Dayton 1, Ohio, U.S.A.

MASTER CRAFTSMAN SHEFFIELD HEADQUARTERS

SHEFFIELD
MANUFACTURE AND MEASUREMENT FOR MANKIND

velopments of our product design section into production - ready equipment for the metal finishing industry, in a sense, making tomorrow's equipment available today. One of our latest projects is the standardized fully automatic plater, designed expressly for the smaller plating shop which wants fully automatic cycling of plating operations. This new unit offers really amazing versatility of operation and is well within the means of the majority of job shops."

Thermostat Test Chamber

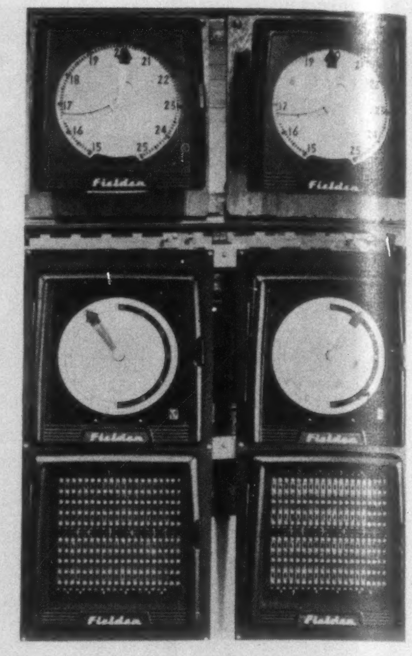
RAPID testing of thermostats for quality control purposes is made possible by a new model thermostat test unit announced by Statham Development Corp. Costly rework time can be reduced by cycle testing thermostats and eliminating all erratic units prior to assembling into the final product. The unit features a low heat inertia test chamber which allows the temperature to reach equilibrium rapidly for any test conditions. The temperature may be controlled manually, or controlled automatically by the thermostat under test.

Dedication Ceremonies Feature Magnetic Tape Applications

LATEST industrial applications for magnetic recording ranging from video tape recording and geophysical exploration to the quiet strains of background music in an office were featured at dedication ceremonies of Minnesota Mining & Mfg. Co.'s Research Center. The firm's "Scotch" brand instrumentation tape was shown in a number of industrial recording applications. Highlight of the dedication, attended by top industrialists from over the nation, was a cross-country color telecast by video tape recording. Originating in New York and recorded and reproduced by Radio Corp. of America's engineering and research group on 3M magnetic video tape, the telecast was termed "a convincing demonstration of the practicality of RCA's video tape recorder." Bing Crosby Enterprises—also a leader in the video tape recording field — demonstrated by means of motion pictures its wide-band "radar recorder" built for the Air Force for use in recording the images of radar screens. This unit is similar to the firm's video tape recorder which was first demonstrated some time ago.

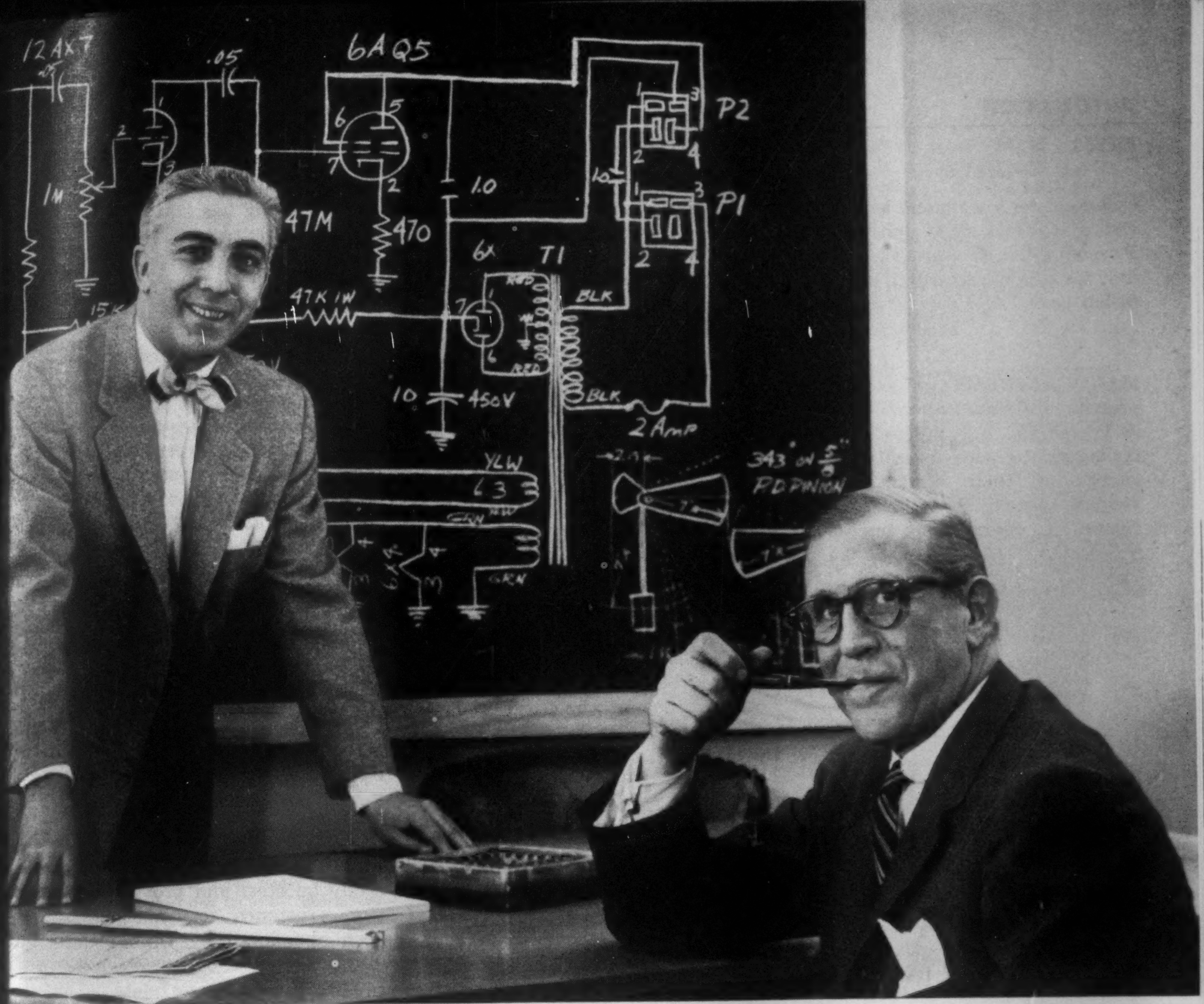
Automatic control of machinery by magnetic tape was demonstrated by Automation Corp. of America, a division of Magnesync Mfg. Co. Ltd. A Diamond milling machine operated automatically by magnetic tape of the 35 mm variety was shown. Use of tape recording for seismic recording in geophysical exploration for oil deposits was demonstrated by the Techno Instrument Co. This was done by a working model of a typical blast-recording operation as well as by demonstrating the firm's equipment which records on magnetic sheets.

In the telemetering field, Ampex Corp. employed a display showing graphically how radio signals from a test rocket are sent back to the ground and recorded on tape for later replay in the laboratory. In the field of office dictation, too, progress in tape recording was shown by a display of various magnetic recording dictation units. Included were the Pierce Co.'s and



INDICATING scanner monitors a variety of process variables including level, temperature, thickness, tolerances, weight and pressure. Unit introduced by Fielden Instrument Div. of Robertshaw-Fulton Controls Co. can keep a steady check on 48 or more steps in a manufacturing process. Two units illustrated are designed to monitor temperatures. Top section of instrument indicates temperature; middle section indicates which step is being monitored. If temperature deviates from prescribed setting for any step, instrument will stop automatically, actuate alarm device, and show attendant both location and extent of variation.

MECHANIZED, continuous, direct gas-fired furnace with cooling chamber has been installed by the Fremont Foundry Co. A Surface Combustion Corp. furnace anneals and stress relieves medium strength grey iron castings at a higher rate and with more uniform results than prevoiusly obtained. Return conveyor and furnace require only half the floor space required for same production utilizing car-bottom type furnace. A timing device on charging mechanism control permits selection of proper cycle for optimum operation.



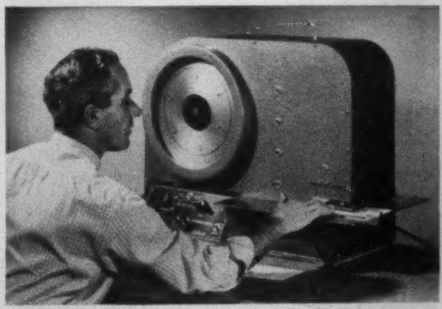
They wanted to change pounds to volts

ter a hundred and twenty-five years of scale
gineering it was easy!

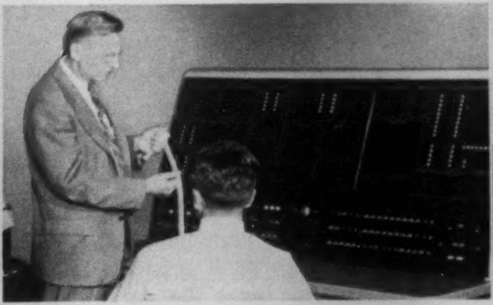
Fairbanks-Morse Scale Engineers sought
d found the practical way to adapt modern
ctronic principles to one of man's oldest
mmercial activities—the accurate weighing
items of trade.

The result is the new Fairbanks-Morse Elec-
nic Scale that brings weighing information
ht to your desk from any spot that is too
mote, too hot or too dangerous.

Only from Fairbanks-Morse can you get
ch originality and soundness of *new* design
at assures outstanding performance. When
xt you need a scale . . . or a pump . . . an
ctric motor . . . or a diesel engine, look for
e famous F-M Seal. For 125 years it has
ood for the finest in practical engineering.
irbanks, Morse & Co., Chicago 5, Illinois.



The Secret is this desk-sized electronic instrument that is direct reading; direct indicating—no manual switching or mental additions. Memory circuit prevents printing unless true balance exists.



The Result is that indications can be brought from remote locations to a central spot and integrated into other automatic electronic operations for faster, more complete utilization of weighing information.

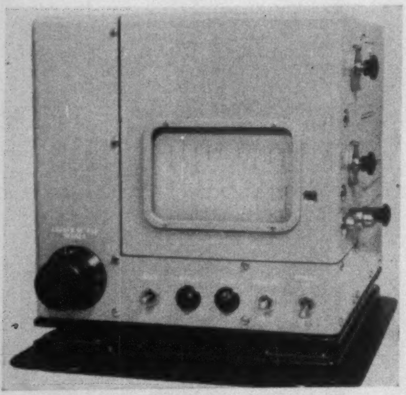
FAIRBANKS-MORSE

a name worth remembering when you want the best

CALES • PUMPS • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

Comptometer's magnetic belt units and a tape cartridge unit by the Permoflux Co. as well as a Revere unit for general recording and dictation use.

MANUFACTURER of complete process instrumentation, Fischer & Porter Co. has promoted four managers to vice presidents in charge of their respective divisions. Among those named was **Robert A. Stern,** who has been appointed vice president, Data Reduction & Automation Division. "These four men have been given the new status because the increasing size and diversity of our operation demands that the management function they serve be given full recognition," **Kermit Fischer,** president and founder of the firm, said. In addition to the manufacture of indicating, recording and controlling instruments, Fischer & Porter makes chlorinating equipment for treatment of water, sewage and industrial waste, complete data reduction and automation systems, and precision-bore glass tubing. Stern, vice president of the Data Reduction & Automation Division, was founder and president of Digi-Coder Corp. and Electrical Development Co. Inc. He came with Fischer & Porter in February 1954, when the Hatboro company purchased those two firms. He developed the F & F automatic logger, a packaged data reduction system which integrates with industrial instrumentation for such functions as automatic process control, computation, statistical analysis, and cost accounting. He is a member of the Instrument Society of America. The three other managers who were promoted are: **Louis H. Aricson,** vice president, International Division; **Nathaniel Brewer,** vice president, Research; and **Edward J. Querner,** vice president, Manufacturing.



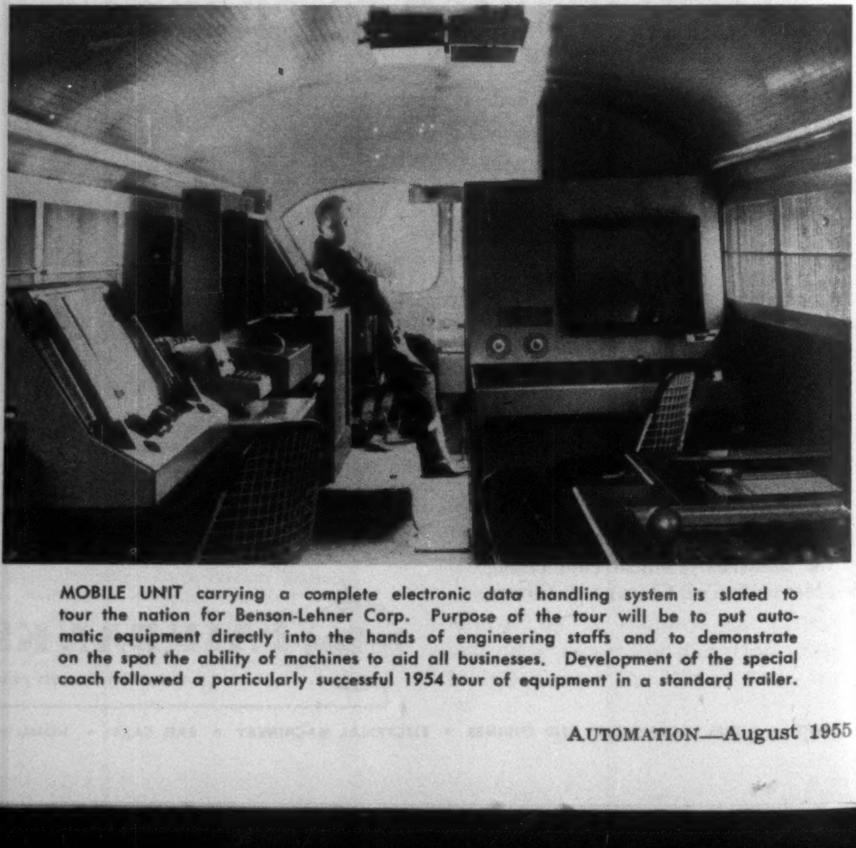
FIXED STYLUS recorder, utilizing 210 channels for direct writing on a 5-inch wide electrosensitive chart has been developed by Radiation Inc. Unit is adaptable to analog, digital or sequential data recording and operates from 115 volt, 60 or 400 cycles per second, power supply. It is designed for airborne as well as ground applications.

Machine Tool Automation

MAJOR, long-range engineering program to develop automatic control devices and systems for expanded automation in the machine tool field has been undertaken by Minneapolis-Honeywell Regulator Co. **Glenn E. Seidel,** vice president of engineering has stated that machine tool automation represents a new and highly specialized field, requiring the development of specialized products and techniques. Honeywell development work in this field will be carried out by a newly formed machine control group composed of a staff of automation engineers headed by **John Rudolf,** formerly supervisor of automation for Honeywell's Minneapolis operations. The new group's first development—a punched-tape type electronic control system that converts a precision boring machine to automatic operation—has been announced. The automatically controlled machine is designed for the company's own use and already is turning out precise gear trains for aeronautical controls.

New Chromium Plate Better Barrier to Corrosives

PRODUCTION plating process that deposits a chromium plate directly on steel and provides superior resistance to corrosion has been announced by United Chromium Inc. Called "Crack-Free Chromium," the new plate is de-



MOBILE UNIT carrying a complete electronic data handling system is slated to tour the nation for Benson-Lehner Corp. Purpose of the tour will be to put automatic equipment directly into the hands of engineering staffs and to demonstrate on the spot the ability of machines to aid all businesses. Development of the special coach followed a particularly successful 1954 tour of equipment in a standard trailer.

AN (STANDARD)

For Aircraft, Electronic Instruments, Military, Industrial, and Commercial Applications

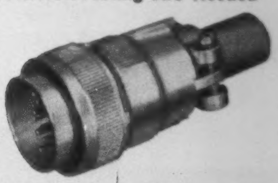
Standard AN-A, AN-B, AN-C... meet Specification MIL-C-5015B. **Plastic inserts.** 15 diameters, 260 insert layouts, 6 shell styles. AN3100 to AN3108 with all accessories. Interchangeability an outstanding feature. Many type assemblies directly available through distributors.

connect with

CANNON PLUGS

AN-E (INT. AN-M)

Where Vibration Resistance and Moisture Proofing Are Needed

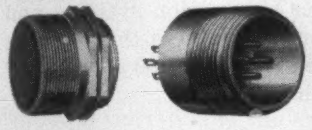


AN-E Series... environment resisting. Replaces "old" AN-M. Meets Specification MIL-C-5015B. Resilient inserts. Completely sealed from cable to cable. Integral clamp and bushing. Grounding lugs. Interfacial sealing with grommet and grommet follower. Available as Interim AN-M with ferrule in place of grommet follower.

The "AN" and associated series connectors offer the

GS (HERMETICALLY-SEALED)

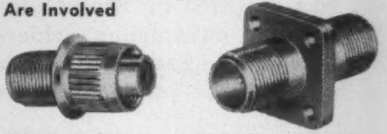
For Use Under Critical Pressure Conditions



Hermetically sealed connectors... with steel shells and contacts to withstand high pressures. Available in GS (AN type), KH, RKH, U, BFH, TBFH. Insulation is Canseal glass material, fused under high temperature to shell and contacts... giving *true hermetic sealing* when soldered or brazed to housing.

STEEL SHELL FIREWALL

For Open Flame Protection Wherever High Temperatures Are Involved



AN-K and Cannon FW Firewall Connectors... offer you the greatest variety of this type of connector. Cannon made the first firewall connector and continues the leader in the field. Wall—or box-mounting receptacles. Straight or angle 90° plugs. Crimp-on contacts. Inserts of asbestos-filled or glass-filled materials.

CONNECTORS SUITABLE FOR **POTTING**

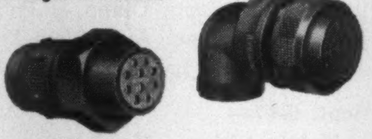
For Resistance to Moisture, Fuel Oil, Gasoline, etc.

CA06 and CA3106 Types... developed for the Bu Aer Standard AN3106 type minus the end bell. Special plastic "cups" supplied for use as a mold while potting the rear of the connector. Weight saving. Grounding means available. Plastic or resilient inserts.

widest selection of types for all applications to Spec. "MIL"

AF, F (VIBRATION PROOF)

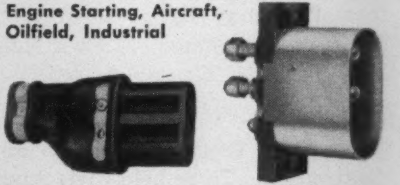
For Points of High Vibration Where Extra Strength Is Needed



Vibration Proof CA310*F—CAO*AF Solid Shell, Resilient Insert Connectors... Feature extra strong coupling nuts... in hex, spline, knurled types for airline use. In wall—or box-mounting, cord-connecting type receptacles. Straight or angle 90° plugs.

AN EXTERNAL POWER

Power Connections—Batteries, Engine Starting, Aircraft, Oilfield, Industrial



CA2551, AN2552, AN3114 and Other Cannon Types Offer Most Complete and Varied Line... in single, double, and three contact fittings. Really rugged! Designed and built for safe, positive connection and long-lasting service.

AN ACCESSORIES

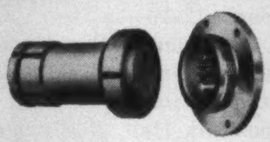
Cable Clamps, Conduit Fittings, Dummy Receptacles, Junction Shells, Dust Caps, Bonding Rings, Bushings, Adapters

Featuring High-Quality Materials and Workmanship... including AN3057, AN-3057A, AN3420, AN3054, AN3055, AN30-56, AN3058, AN3064, AN3066, AN3068, AN3111, 2120, 2245, 17530, 2209, 2182. Adaptable to all makes of AN connectors.

Cannon Plugs—standard of quality for the industry

W

For Underwater and Severe Moisture Conditions



W Waterproof Series... used underwater and on equipment operating in swamps, rivers, lakes, with underground cables — wherever conditions require thoroughly sealed fittings. Exceptionally rugged. AN type inserts. Acme threads on coupling nuts. Special rubber sealing ring. Special heavy duty cable clamp available.

OTHER SERIES... Audio Types–External Power Connectors–Switching Types–dc Solenoids–Guided Missile Launching Connectors–Miniatures and Sub-Miniatures.

40th YEAR
1915-1955
CANNON ELECTRIC
CANNON

Since 1915

Write Today for new, completely revised, up-to-date AN10 bulletin!

Please refer to this Magazine or to Dept. 424

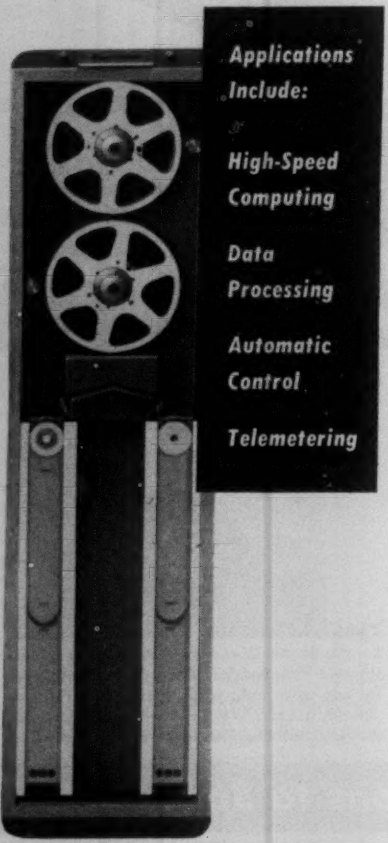
CANNON PLUGS

CANNON ELECTRIC CO., 3209 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles; East Haven; Toronto, Canada; London, England; Melbourne, Australia. Manufacturing licensees in Paris, France; Tokyo, Japan. Contact our representatives and distributors in all principal cities.

DataReader

Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.



PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

END-OF-TAPE SENSING—stops automatically at either end of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

FOR FURTHER INFORMATION WRITE
ElectroData Corporation
Component Sales Division
717 No. Lake St., Pasadena 6, Calif.

ElectroData

An Affiliate of
CONSOLIDATED ENGINEERING CORPORATION
OF PASADENA, CALIFORNIA

ElectroData Corporation maintains a nationwide sales and service organization.

posited free of any structural imperfection that would allow corrosive materials to come in contact with the underlying surface being protected. As a result, it can be plated directly on steel, without the necessity for an undercoat of nickel or copper and nickel.

Other desirable properties of the deposit produced by the new process include low coefficient of friction, excellent adhesion, a nongalling surface and superior ductility as compared to ordinary chromium finishes.

DESIGNERS and manufacturers of electronic computers, Logistics Research Inc. has named **Sir Robert Alexander Watson-Watt** as president and board chairman. World famed for the discovery and development of radar, Sir Robert was knighted by King George VI for this outstanding achievement and was awarded the Medal of Merit by the president of the United States. It is less generally known that he also developed the high frequency radio direction finder, dubbed "Huff Duff" by the U. S. Navy.

In developing the potentialities of Logistics Research Inc., Sir Robert will draw upon the scientific, engineering and management services he also heads. These are Sir Robert Watson-Watt and Partners Ltd., London, and its two North American subsidiaries, Adalia, Ltd., Canada, and Adalia Inc. The immediate program is to guide the development, manufacture and sale of ALWAC III, a low-priced, high-speed, general purpose digital computer that is finding wide use in business, scientific research and government. "Our overall program is to develop wider application and to make available to businesses of all sizes automation systems and electronic computers that to date have been prohibitively priced," Sir Robert says.

MEETINGS AND EVENTS

Aug. 22-23—

National Industrial Conference Board. Electronic and automation symposium, jointly sponsored by Stanford Research Institute, to be held San Francisco. Additional information may be obtained from NICB headquarters, 247 Park Ave., New York, N. Y.

Aug. 24-26—

Western Electronic Show and Convention. To be held Civic Auditorium, San Francisco. Additional information may be obtained from Mal Mobley Jr., Business Manager, 344 North La Brea Ave., Los Angeles 36, Calif.

Sept. 6-16—

National Machine Tool Builders Association. Machine Tool Show to be held International Amphitheatre, Chicago. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

Production Engineering Show. Automation exposition to be held Navy Pier, Chicago. Designed to run concurrently with the Machine Tool Show for complete coverage of mechanisms, instruments and equipment which contribute to automation in production and processing. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-17—

Metalworking Machinery & Equipment Exposition. To be held Chicago Coliseum, Chicago. Additional information may be obtained from Exhibition and Convention Management Inc., 2689 East Overlook Road, Cleveland 6, Ohio.

Sept. 12-16—

Instrument Society of America. Instrument-automation conference and exhibit to be held Shrine Exposition Hall, Los Angeles. Additional information may be obtained from Fred J. Tabery, 3443 S. Hill St., Los Angeles 7, Calif.

Sept. 14-16—

Association For Computing Ma-

chinery. National meeting to be held University of Pennsylvania, Philadelphia. Additional information may be obtained from association headquarters, 2 E. 63rd St., New York 23, N. Y.

Sept. 20-22—
Society of Industrial Packaging and Materials Handling Engineers. Tenth anniversary meeting and exposition to be held Kingsbridge Armory, New York. Additional information may be obtained from society headquarters, 111 West Jackson Blvd., Chicago 4, Ill.

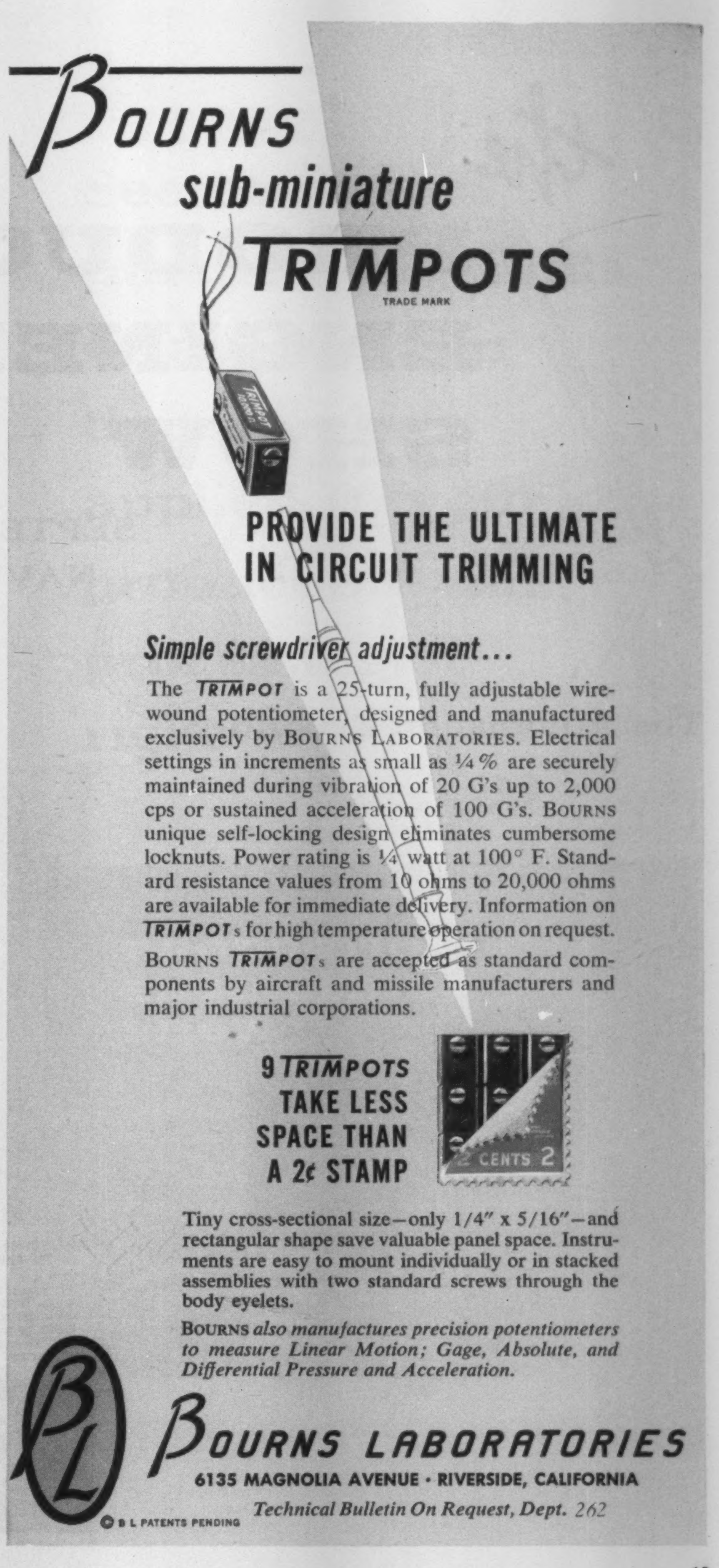
Sept. 26-27—
Radio - Electronics - Television Manufacturers Association. Symposium on automation to be held University of Pennsylvania, Philadelphia. Additional information may be obtained from association headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 28-30—
Technical Association of the Pulp and Paper Industry. Testing conference to be held Sheraton-Kimball Hotel, Springfield, Mass. Additional information may be obtained from Wm. Schoenberg, exhibition chairman, 1878 East 18th St., Cleveland 14, Ohio.

Oct. 3-5—
National Electronics Conference. Eleventh annual conference to be held Hotel Sherman, Chicago. Additional information may be obtained from J. Kocik, c/o Illinois Bell Telephone Co., 208 W. Washington St., Rm. 300, Chicago 6, Ill.

AUTOMATION

"This line has turned out to be extremely profitable"


BOURNS sub-miniature TRIMPOTS
TRADE MARK

PROVIDE THE ULTIMATE IN CIRCUIT TRIMMING

Simple screwdriver adjustment...

The TRIMPOT is a 25-turn, fully adjustable wirewound potentiometer, designed and manufactured exclusively by BOURNS LABORATORIES. Electrical settings in increments as small as ¼% are securely maintained during vibration of 20 G's up to 2,000 cps or sustained acceleration of 100 G's. BOURNS unique self-locking design eliminates cumbersome locknuts. Power rating is ¼ watt at 100° F. Standard resistance values from 10 ohms to 20,000 ohms are available for immediate delivery. Information on TRIMPOTs for high temperature operation on request.

BOURNS TRIMPOTs are accepted as standard components by aircraft and missile manufacturers and major industrial corporations.

9 TRIMPOTS TAKE LESS SPACE THAN A 2¢ STAMP

Tiny cross-sectional size—only 1/4" x 5/16"—and rectangular shape save valuable panel space. Instruments are easy to mount individually or in stacked assemblies with two standard screws through the body eyelets.

BOURNS *also manufactures precision potentiometers to measure Linear Motion; Gage, Absolute, and Differential Pressure and Acceleration.*

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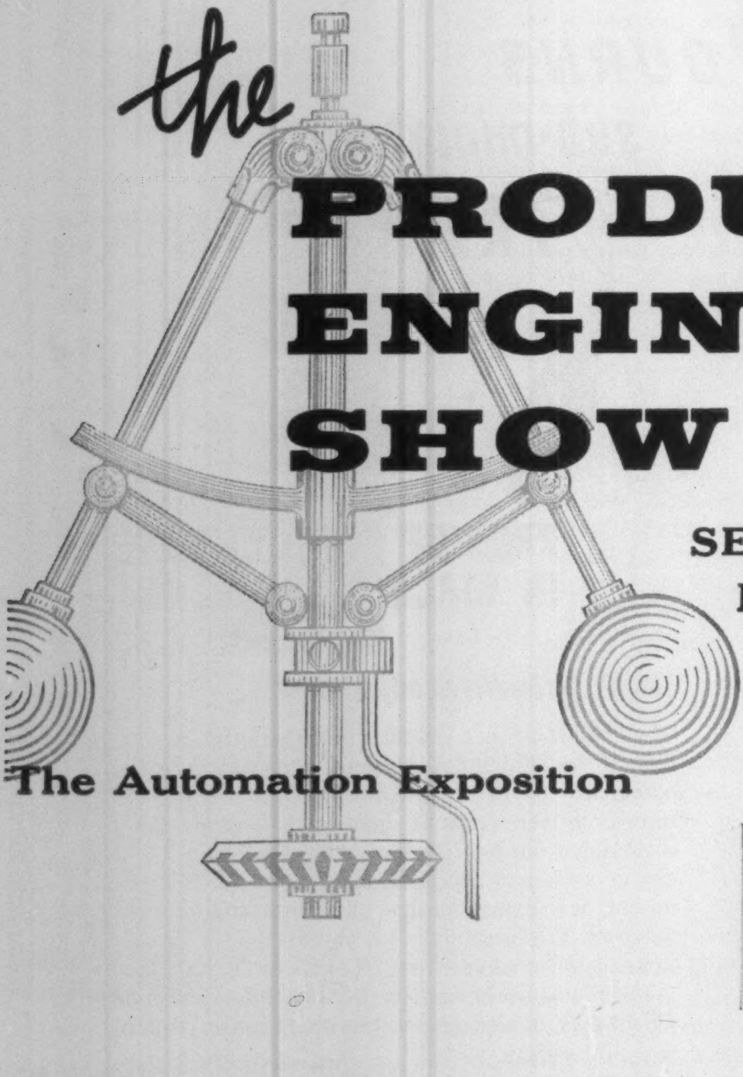
Technical Bulletin On Request, Dept. 262

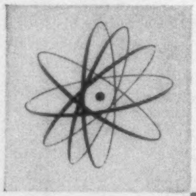
© B L PATENTS PENDING



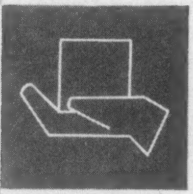
the PRODUCTION ENGINEERING SHOW

SEPTEMBER 6-16, 1955
NAVY PIER, CHICAGO

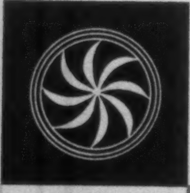
The Automation Exposition



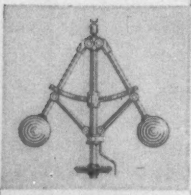
MONITORING EQUIPMENT
such as: Recording and control equipment. Electronic devices. Switches, relays and electrical components. Counters and computers. Mass spectrometers.



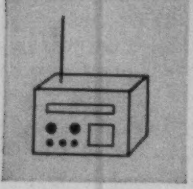
HANDLING EQUIPMENT
such as: Conveyors, Cranes, Hoists, Monorails, Pneumatic tubes. Clamping, rotating and positioning equipment. Loading and unloading equipment.



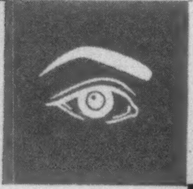
EQUIPMENT COMPONENTS
such as: Air and hydraulic mechanisms. Mechanical activators. Brakes, clutches and other drive mechanisms. Electrical, air and hydraulic motors.



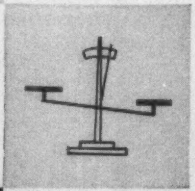
GOVERNING EQUIPMENT
such as: Devices for tramp iron removal. X-ray, fluoroscope and photocell devices. Limit switches and governors.



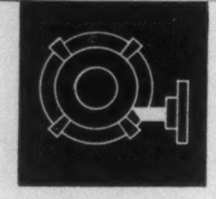
COMMUNICATIONS EQUIPMENT
such as: 2-way radio. Telephone and paging systems. Teleprinters and facsimile. Industrial television. Special signaling equipment.



INSPECTION AND GAGING EQUIPMENT
such as: Air gages. Strain gages. Beta ray thickness gages. X-ray gages. Optical gaging equipment.



SPECIAL PRODUCTION EQUIPMENT
such as: Continuous heat treating and drying furnaces and ovens. Abrasive blasting and other finishing equipment. Engineered paint systems. Weighing and proportioning equipment.



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By FLOYD G. LAWRENCE Detroit Editor

A FIELD IN ITSELF

MORE THAN ONE automated machine tool line that was a shiny cost cutter a year or two ago is a maintenance dog today. The problem hasn't yet become an epidemic, but it's common enough that management is reported beginning to take a new look at the automation-machine relationship.

In many cases the automation mechanisms and conveyors cost as much as the machine tool. Yet while the machine may last for many years, wear in the mechanisms unconnected with machining can cause the whole operation to get out of whack, says one observer—obviously a machine-tool builder.

He notes that lubrication of conveyors operating in the dust and chip atmosphere is no picnic. Likewise, keeping locating stops clean and on-tolerance creates a problem for the machine tool builders whose achievement of accuracy is contingent on this condition. Automation, he feels, must be as carefully designed as the machines it serves if comparable service is to be expected. He feels that present automation is relatively a makeshift proposition in contrast to the precision of the machine tools supplied.

Immediate problems in addition to precision design include the need for rugged components. Particularly vulnerable, he feels, are limit switches. He also sees a need for standardization of rails, pulleys, switches, hydraulic cylinders and valves, etc. That's because a maintenance man is often confronted with a replacement problem he can't solve until the exact part originally supplied is duplicated. Standardized mountings, sizes, capacities, etc. would do much to facilitate quick machine repair.

Before, such standardization was not considered a problem. Now as the number of automated lines grows larger and the lines grow older, replacement and maintenance are coming to the fore and it's a cinch standardization will be moving into the limelight.

Looking ahead, he feels the master mechanic will continue to increase in importance, not only as the man who must keep the machine going but as the man who anticipates the maintenance problems and aids in the design of the machines.

Other trends he notes in the machine tool field are the increasing stocks of standard components which can be assembled in various combinations into special purpose machines. Even when volume is relatively limited, standardization pays off in saved design time as well as certain volume discounts. Then, too, in the event of failure the part can quickly be shipped from stock to the customer without the delay of making another.

One interesting idea he throws in is his thought that inspection seems to be headed toward primary operation status. He feels there is a trend to make the inspection station the key of the line serving it, with machining operations set up to submit the part properly oriented for inspection.

As to his fundamental point, however, that the interrelationship of machines and automation links requires a closer look it seems likely that many will agree. Often the machine tool builder and automation supplier do not work closely on the project since both may be working for a third contractor. All too often automation units are turned out with primary attention given to their function and not enough to the length of service, maintenance and precision positioning function required under adverse conditions.

There is some talk that machine tool builders will be forced to make more and more of their own automation equipment as time goes along. One observer notes that the handling equipment is trending to become more a part of the actual machine and thus is a logical extension of the machine tool builder's field. A ready example of the point is Michigan Tool Co. which built the automation for Roto-Flo spline rolling equipment it delivered to Buick for axle shafts.

On the other hand, it may be argued with equal credibility that handling is not merely concerned with delivering the part to the cutting tool but also with transportation between machines and between parts of the plant. Handling, this reasoning points out, is like a railroad in the plant and having equipment automated by the builder can create problems like trying to join regular track with narrow gage.

From all this one thing seems very clear: A need for standardization in automation methods, components, conveyor dimensions, work position heights, etc. There is much justification for the view that between-machine automation has plenty of room to exist as a field in itself requiring special techniques.

Standardization of automation methods, processes and components would help to solve that problem.

(Advertisement)

Report to Cylinder Users . . .

Here at Miller Fluid Power we have a pattern which we follow. A goal at which we are shooting. The pattern isn't too simple. And the goal isn't an easy one. But we've been making progress. Our position right up in the van of the industry proves that.

Our job is the production of cylinders. Basically, there's nothing anyone can do to alter a cylinder. It was old a hundred years ago. It probably won't change basically in another hundred years. But in the details of the cylinder, change is the major element.

Which is very much like industry itself. Basically industry has not changed since free enterprise was conceived on this continent. But in every detail it changes from year to year.

It's the Thousandths That Count

There was no single big thing wrong with the cylinders being manufactured yesterday. Just a lot of little things. So Miller Fluid Power made the improvement of little things its business.

We experimented with new materials and made safer, more dependable steel heads and caps. We hard-chrome-plated 110,000 PSI yield point steel to improve radically the piston rods. We raised the efficiency of operation to new peaks. Striving for quality in the smallest detail we improved in a dozen parts which are hidden from sight.

For instance, most cylinders leaked in operation. Miller made one that wouldn't leak. To prove it, we went away out on a limb and guaranteed leak-proof operation. And made the guarantee stand up.

We Learn by Listening to You

We saw our customers as thousands of men in thousands of shops wrestling with thousands of production problems. We made those problems ours and produced cylinders to whip those problems. Maybe we didn't revolutionize the cylinder business in the process. But we sure helped. We know that.

We learned to produce what we believed was the best cylinder on earth. We also learned that the best cylinder today wouldn't be good enough tomorrow. So, with the good one in production, we listened some more, experimented, and came up with a better one.

Miller Fluid Power is a young company in an old field. We are young, progressive, and willing to listen. We innovate without being prodded.

Discussion is a Two Way Street

On occasion we like to have others listen to us. Especially when what we have to say will help our customers. That is the idea behind our College of Cylinder Knowledge. We know a lot about cylinders. Though not as much today as we will tomorrow or the day after.

In our College of Cylinder Knowledge we try to show you what good cylinders can do for you. And what you should demand in any cylinder you buy. We meet other men who know what they want in a cylinder. We listen to their wants and try to explain what perfection in detail means.

We believe that when the users of cylinders sit down across the table from the producer who is trying to make the best, better cylinders result.

We'll be carrying that belief into the Production Engineering Show at Navy Pier in Chicago on September 6. Our College of Cylinder Knowledge booth will be open for that kind of discussion. We'll listen and learn.

The only way we can learn is from you. We can help you. But not until you've dropped that problem of yours in our lap. Your problem contains the stuff of which the better cylinder will be made. The cylinder that will have that quality plus which we like to think is the stamp of Miller Fluid Power.

Remember this when you see the sign over Booth 1819-23. We'll be there to listen to your suggestions, demands and questions. Also, because we are in the cylinder business, we'll be there to show you a cylinder you will want to buy.

Frank Flick

President

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Production Engineering

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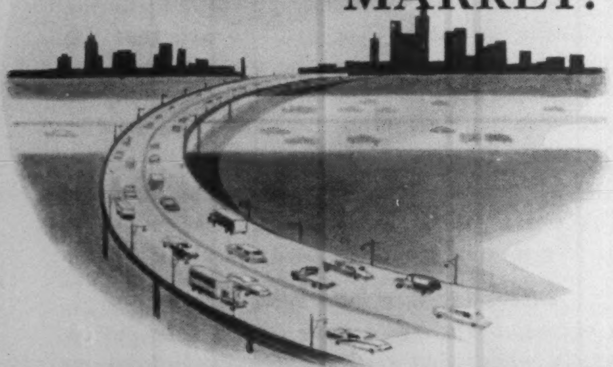

★ By 1965, the experts predict there will be 80 million automobiles in existence, as compared to some 50 million now.

For that traffic load, more than 50 billion dollars will be needed to rebuild the 3,350,000 miles of existing roads and to build new super highways.

Each million dollars of highways requires between 420 and 450 tons of steel. Each automobile averages about 3,500 pounds of steel, plus many pounds of copper, brass, aluminum, rubber and plastic.

Will you lose out competitively on this big market on poor quality of product or slow production equipment? Good equipment brings down production costs and improves product quality.

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GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

AUTOMATION

Automation and Dollars

Few businessmen overlook the importance of cost accounting in their operations. Business success in a competitive economy depends to a large extent on accurate and detailed cost data. But in the evolution of automation, new procedures may be necessary to provide suitable and adequate costing.

In an interesting article in a recent issue of the *NACA Bulletin*, A. E. Puutio places the problem in bold relief:

"Studies of present accounting procedures will, in most cases, reveal that they do not lend themselves fully to automation. Changes and modification must be developed and put into effect before they can be aligned to reflect new developments in manufacturing methods. In the first place, distribution of overhead under present cost systems, especially those based on a direct or prime labor cost basis, may no longer furnish accurate costing under automation . . . a similar situation exists with respect to the other common bases which are used for applying overhead to products . . . The ideal solution may require a completely new method for allocating overhead to the various producing units or products".

It is not too early to investigate and plan for automation. Many problems will arise and require effective solution for realization of desired and practicable results. Even now as competition increases and broader markets are being sought, accurate and close control of costs is mandatory.

Adequate foresight in gearing costing operations to present a true and accurate picture without present delays will guarantee suitable basis for future plans. It is wiser to be prepared too soon than too late. Effects of continued changes resulting from the successive steps toward automation will be minimized through good planning.

Now is the time to institute thorough and well-organized research to prevent possible confusion and eliminate possible losses in revenue or production as methods become more and more automated. Automation offers management a path to real dollar savings but only if accounting reports and records reflect a complete and accurate picture for evaluation and action.

Bolz

EDITOR

Predetermined quantities of bulk materials can be automatically fed to succeeding operations by systems combining various methods of handling and weighing. Compounding of several bulk ingredients by weight can be automatically controlled from a remote panel with such systems

METERING BULK MATERIALS

By **I. H. RICHARDSON**
President
Richardson Scale Co.
Clifton, N. J.

RECENTLY THE STATEMENT was made by a General Electric executive that because of normal growth of population and the expanding economy, his company would have to double its output in the next ten years to keep up with demand. He went on to say that to accomplish this, only 10 per cent more labor would be available to them. That corporation is no exception, and we have to face the fact that ten years from now labor should be almost twice as productive per man-hour as it is today. This means we must make a tremendous increase in the productivity of our national labor force, and already great progress is being made wherever we look.

Vending machines and automatic elevators have changed public places. Punched cards have given single individuals the ability to process mountains of business details. Productivity in other areas has been increased with prefabricated houses; automatic feeding, watering and cleaning equipment on the farm; and the turnpikes which almost double the ton-mile production of truck drivers. These and many new applications of engineering ingenuity must be combined to give the required increase in productivity.

Fortunately bulk materials have long been handled automatically and also weighed automatically, many since the turn of the century. But something new has to be added to apply more elaborate weight control to processes which are becoming increasingly automatic, complex and exacting. Instrumentation is required for remote control and recording; for automatic adjustment of an already automatic scale as signaled by a feedback circuit in a closed loop process to correct for varying tare, or for varying moisture; to respond automatically to data received on a punched card or in turn to produce a punched card with coded weight data including calculations derived from the weight of a passing load.

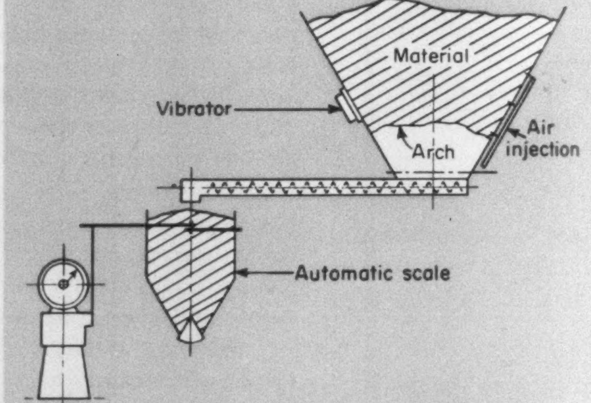


Fig. 1—Arching in a hopper bottom bin may be overcome by selective use of air injectors or vibrators. Such accessories often require operator judgment to prevent excessive packing or liquefaction of the material

Design for Automation

Mechanical design of bulk handling and weighing installations must be sound before elaborations

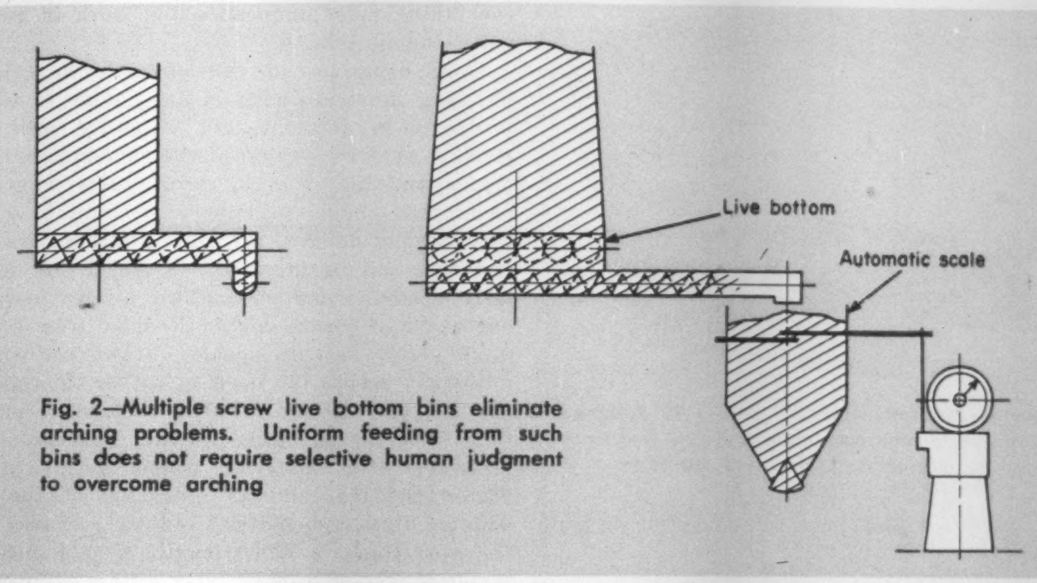


Fig. 2—Multiple screw live bottom bins eliminate arching problems. Uniform feeding from such bins does not require selective human judgment to overcome arching

can be worthwhile. As automation is increased, fundamental mechanics become of increasing importance, and let no one make light of them. Not only do we have an arching material like flour, but there are others ranging from cherry red clinkers to ice cubes, from dense ore concentrates to cork dust, from the tiny spheres of clover seed to 18-inch lumps of Solvay limestone, from micron ground bauxite which runs like water to molasses dairy feeds which stick to everything they touch. Materials themselves may be abrasive, hygroscopic, corrosive, toxic, explosive, and more recently, radioactive. Sanitation must be observed in handling food products like milk; insecticides must not escape to poison the air; plastic powders must be protected from outside dust; flaked chemicals must not be broken, nor walnuts be cracked, nor fruit be bruised; nor dry mixtures be allowed to segregate.

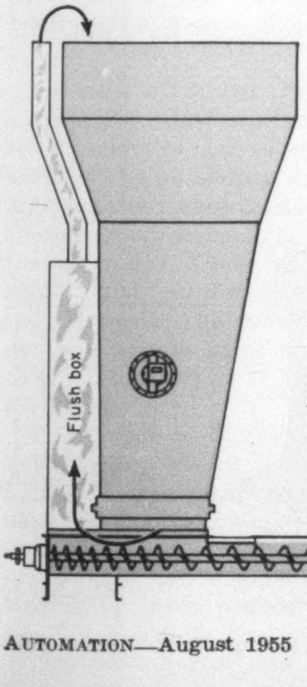


Fig. 3 — Avalanching of material can be handled with an adjacent flush box which provides an avenue of low resistance to absorb surges but is promptly emptied by the screw conveyor

Perfect instrumentation for automatic weighing is worthless if a material sticks in a bin or avalanches and floods uncontrolled from the bin. This problem can be illustrated by a simple weighing station, *Fig.* 1, handling flour for instance from a hopper bottom bin under the control of an operator with manual dexterity and human judgment. There must be a controlled stream going to the scale, and so long as he is there the system works well. If the flour arches in the bin, he stops the screw and injects compressed air, or starts a vibrator on the bin wall to break the arch. When the material flows again he stops the vibrator and turns off the air. We could apply automatic cycling to this weighing operation and automatically stop the screw when a prescribed weight has been delivered; but what was a workable system under manual control may suddenly become a dismal failure. There is no one to exercise judgment and break an arch if it occurs. If we try to make the vibrator and airline work automatically we may pack the flour into a solid mass, or we may liquefy it to such an extent that it flows like water. The human judgment to get a controlled feed to the scale is gone.

Rather than devise a mechanical substitute for the operator's judgment, we can devise a system which works without any judgment. For example, *Fig.* 2 illustrates a bin with belled rather than hoppered sides, so material cannot arch in the first place. To get material out of such a bin requires a live bottom of multiple screws feeding into a common conveyor leading to the scale. This is more expensive, but it works reliably just as

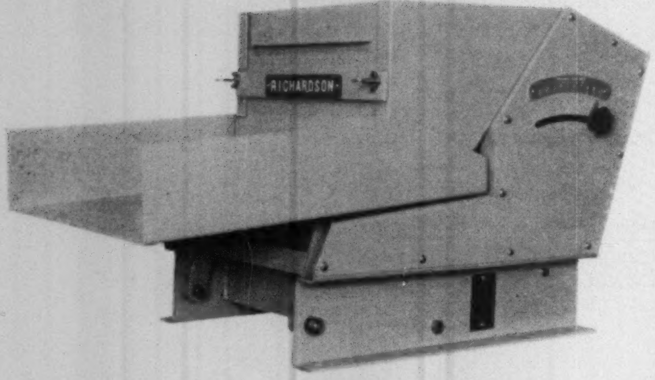


Fig. 4—This mechanical vibrating feeder is designed to have a relatively high amplitude and low frequency as compared to magnetically actuated vibrators

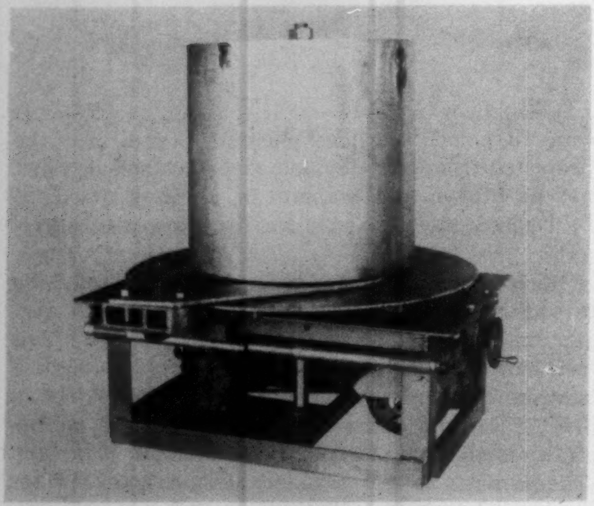


Fig. 5—Sticky materials can be fed from a bin which revolves. A stationary plow shears off a ribbon of material from the revolving mass

everything must unquestionably work in an automatic installation.

Some examples of developments in materials handling illustrate what is being done to simplify problems in automatically weighing bulk materials. A modern version of the time-honored screw feeder and bin, *Fig.* 3, incorporates what experience has shown to improve feeding to a scale. The large opening to the bin encourages free flow, and this can be increased in length for particularly obstinate materials. Two screws instead of one would of course double the inlet area. A varied pitch screw in this opening draws the material uniformly across the opening rather than all from the tail end as occurs with a constant pitch. A flush box in the back provides a path of least resistance for material which may avalanche within the bin, and an extension of the screw empties this immediately and so prepares it for the next flush. A short length of tube forms the material into a moving plug before it passes on to the expanded casing. A section of shorter pitch at the discharge end of the screw reduces pulsation, and the delivery is still further smoothed out by stopping the flight a few inches short of the discharge. Outboard ball bearings prevent grease contamination, and double bearings on the drive end will eliminate deflection or whip of the screw shaft when running at high feeding speeds.

Illustrated in *Fig.* 4 is a mechanical vibrating feeder of English origin, designed to have a high amplitude and low frequency (1800 per minute) as compared to magnetic vibrators which have just the opposite, high frequency and low amplitude. Soft materials sometimes tend to absorb vibration, and these will react much more favorably to the high amplitude of mechanical vibration.

Difficulties in bulk storage and feeding of certain sticky materials, especially where small but accurately measured quantities are called for, has baffled engineers trying to handle them. One answer, shown in *Fig.* 5, is a revolving bin with a plow arranged to shear off a stream from the revolving mass. Acting almost like a lathe tool, this plow could conceivably empty a bin filled with putty.

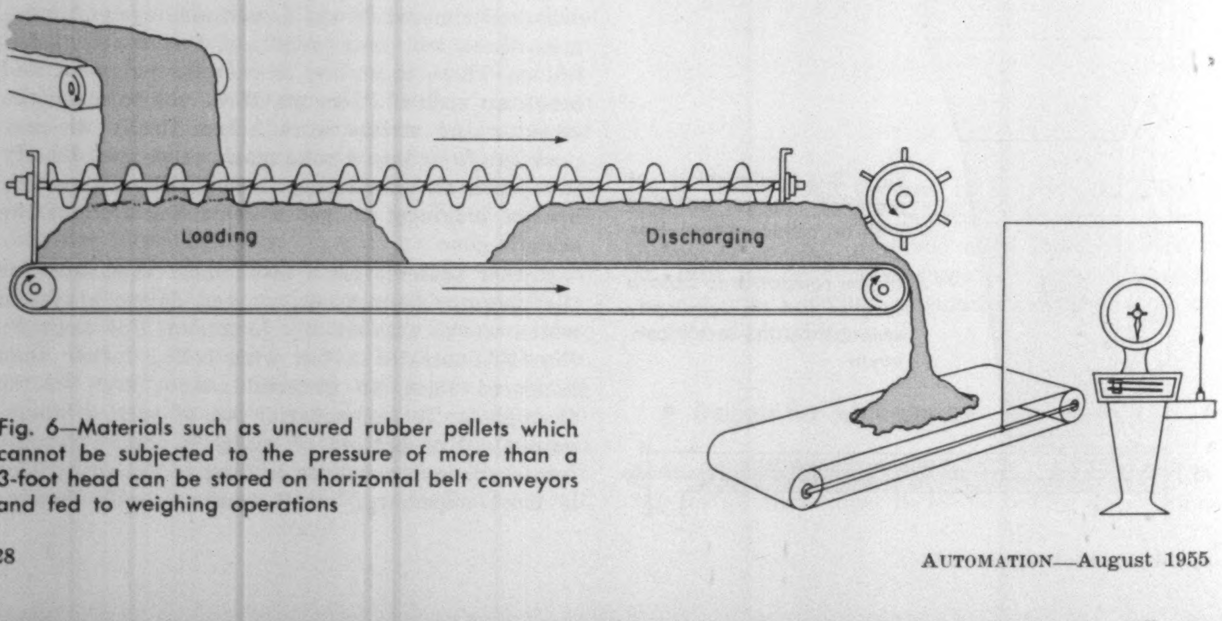


Fig. 6—Materials such as uncured rubber pellets which cannot be subjected to the pressure of more than a 3-foot head can be stored on horizontal belt conveyors and fed to weighing operations

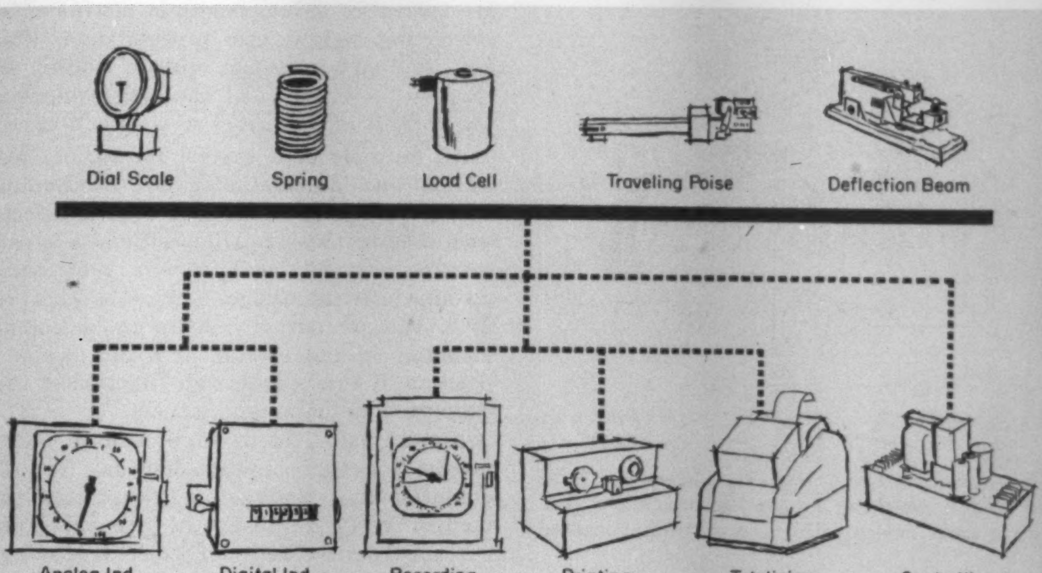


Fig. 7—Load sensing devices supplementing or replacing the simple beam permit usage of recorders and controllers which are the basis for automatic systems or remote supervision and control

Uncured rubber pellets will bunch together if subjected to the pressure of more than a 3-ft head. A method for horizontal storage of these pellets is sketched in *Fig.* 6. Here a belt conveyor which is not moving can be loaded to a depth of three feet over its entire length by a screw conveyor without a casing. The screw is above and parallel to the belt and keeps skimming off the top of the pile of incoming pellets. To discharge the material, both the screw and belt operate and a revolving picker at the head pulley produces a uniform break-away.

▶ Batch vs. Continuous Weighing

Selection of the weighing process itself is also a point for consideration. Weighing of bulk materials may be by dead-weight batch weighing units or by in-motion continuous belt weighers. My company makes both kinds and each type finds specific applications. The continuous weigher has the advantage of low headroom and apparent simplicity; and will deliver a steady stream of material. However, the continuous weigher is not as accurate as the batch weigher and is not sufficiently accurate for a great many weighing applications.

Comparison of the two systems for an identical requirement readily shows why batch weighing is inherently more accurate. Suppose we are to deliver 300 pounds of material per minute. With a continuous belt weigher we may have a belt speed of 100 feet per minute which will mean a belt loading of three pounds per lineal foot of belt. If there is one foot of belt on the weighing span at any one time, the scale is set for a 3-pound material load. The common accuracy specifications of 1/4 of 1 per cent would require sensitivity to 1/8-ounce variation. Inflexibility of the belt, friction on the skirt plates, variation in shear characteristics of the material, or fluctuations in belt speed will mitigate against accuracy with this system.

With a batch weigher, a 300-pound weighing can be accurately released every minute by an electric timer. For the single 300-pound load 1/4 of 1 per cent accuracy will be met within a variation of 12 ounces per weighing. Material from a batch weigher can be streamed out where required; and the batch method permits separate identification of the loads weighed.

▶ Components and Systems

Every weighing scale incorporates one or more load sensing devices. From time immemorial the simple beam or steelyard with a sliding poise has been used as a sensing device. Other methods still do not excel it in accuracy and simplicity. Unfortunately the simple beam does not lend itself directly to remote indication, recording or control, so other devices have been developed to supplement it or replace it entirely.

These include pendulum dial scales; calibrated springs; load cells of electric, hydraulic or pneumatic principle; the traveling poise which automatically seeks a position of equilibrium or goes to a predetermined point on the beam; and the

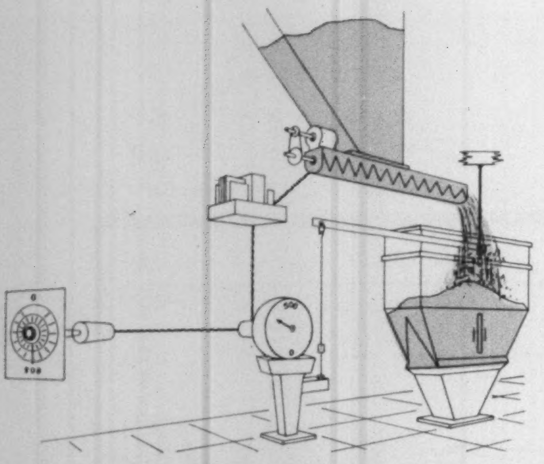


Fig. 8—An automatic batch weighing system can have the feed into a weighing hopper automatically controlled by a scale device which is preset for a desired weight

deflecting cantilever, a combination of a spring and a load cell. These load-sensing devices open the way to instrumentation which would never be possible with the simple beam, see *Fig.* 7. The dial scale is itself an analog weight indicator, and by a servomechanism can drive a follower for remote indication. The counter, especially when servo driven and geared for a very high speed, can be made to provide digital indication of the load sensed by any of the various devices. The remote recorder, printer, and totalizer, all servo-driven, are typical of developments in instrumentation for converting weight into process data. Finally, an amplifier and relay can operate motors, solenoids, etc., to put mechanical handling equipment under the control of the scale or weight sensing device.

An example of a system for remote weight selection and automatic control of feeding for a batch weigher is depicted in *Fig.* 8. Selection of a weight at a panel board positions a precision potentiometer and establishes a reference voltage on an electrical bridge. This voltage is compared to a voltage output set up by a potentiometer mounted on the spindle of a dial scale. Angular position of this spindle is a function of the weight supported by the weighing beam.

At the point of voltage balance between the weight selector potentiometer and the dial scale potentiometer, a signal is transmitted through a control relay resulting in the energizing of a current-sensitive relay. This control relay is a 2-tube instrument amplifier with the current-sensitive relay in the plate circuit of the final voltage amplifier stage. The impulse so delivered is fed into a sequencing control circuit which in turn controls the feeder motor. For proportioning multiple ingredients in a single weigh hopper, several weight selecting verniers and potentiometers can be used. These would be set at increasing values for cumulative weighing, or the scale can discharge the contents each time, making consecutive weighings according to the values established on the various weight selectors.

Such systems offer opportunities for weight

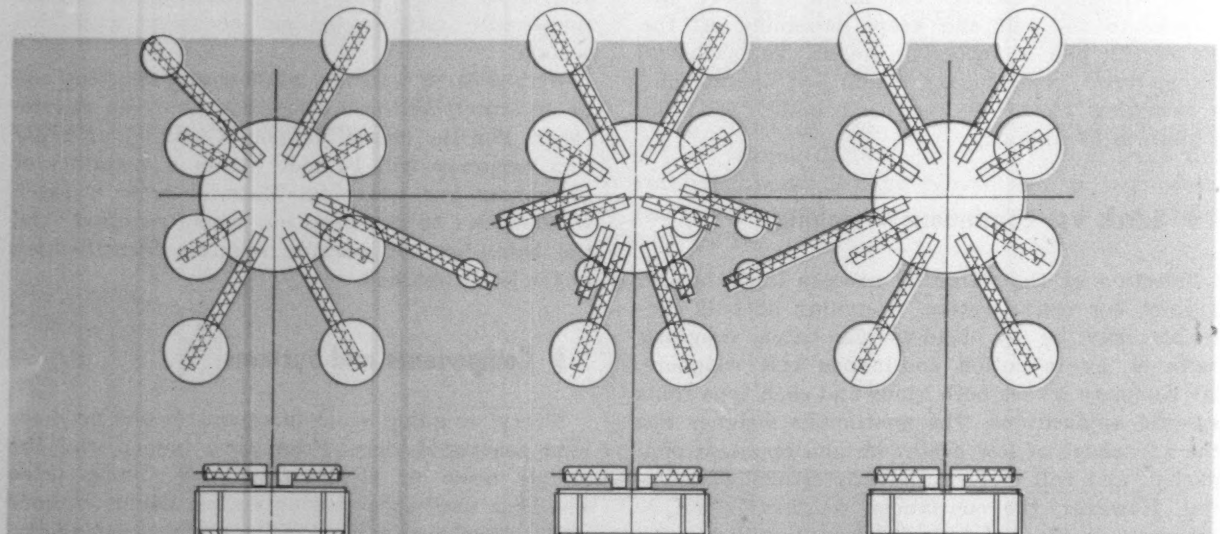
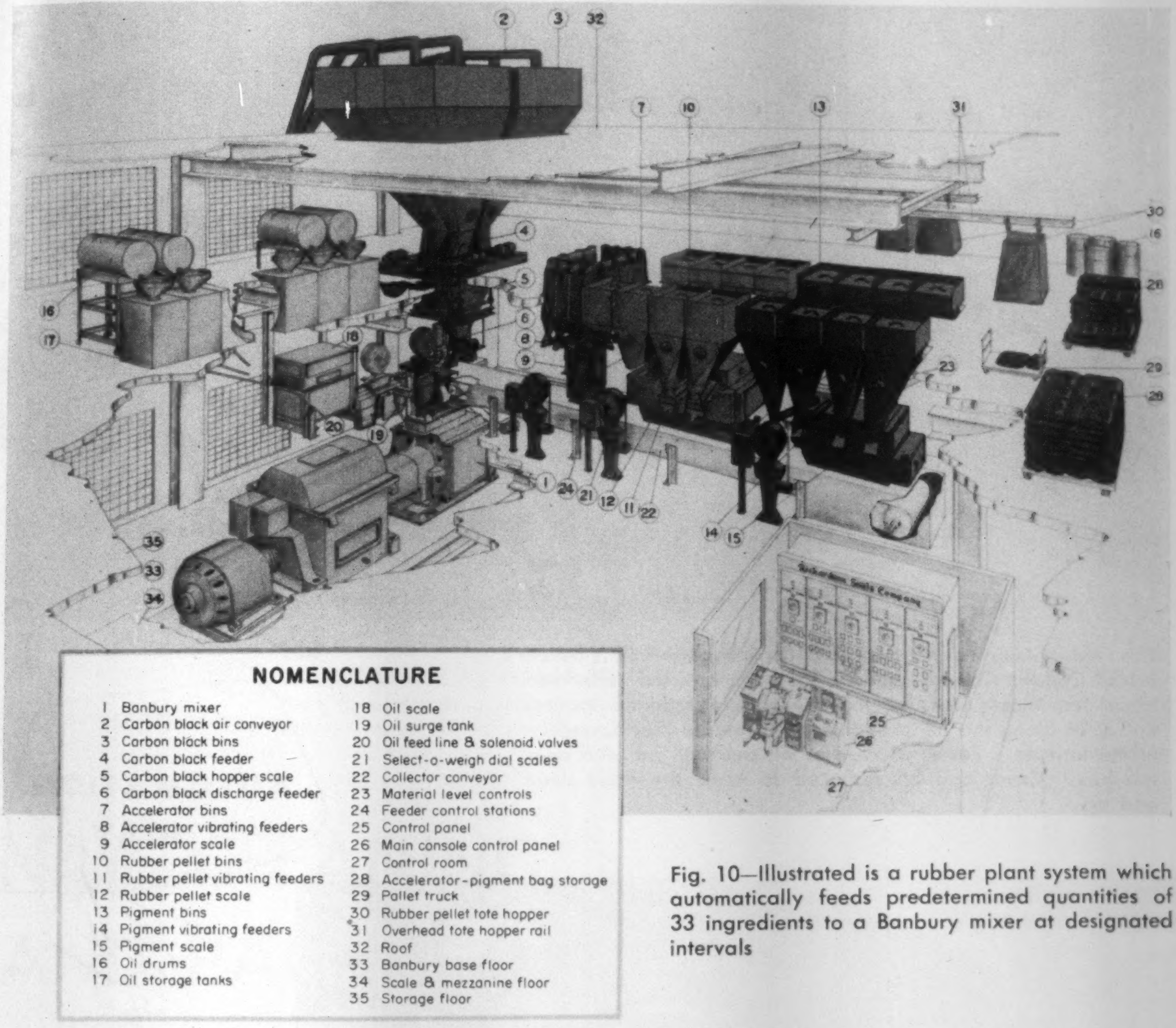


Fig. 9—Shown in this sketch is a system which can draw 30 different cattle feed ingredients from their respective bins. Screw conveyors carry the materials to three automatic scales which weigh out ingredients in the desired proportions



NOMENCLATURE

1	Banbury mixer
2	Carbon black air conveyor
3	Carbon black bins
4	Carbon black feeder
5	Carbon black hopper scale
6	Carbon black discharge feeder
7	Accelerator bins
8	Accelerator vibrating feeders
9	Accelerator scale
10	Rubber pellet bins
11	Rubber pellet vibrating feeders
12	Rubber pellet scale
13	Pigment bins
14	Pigment vibrating feeders
15	Pigment scale
16	Oil drums
17	Oil storage tanks
18	Oil scale
19	Oil surge tank
20	Oil feed line & solenoid valves
21	Select-o-weigh dial scales
22	Collector conveyor
23	Material level controls
24	Feeder control stations
25	Control panel
26	Main console control panel
27	Control room
28	Accelerator-pigment bag storage
29	Pallet truck
30	Rubber pellet tote hopper
31	Overhead tote hopper rail
32	Roof
33	Banbury base floor
34	Scale & mezzanine floor
35	Storage floor

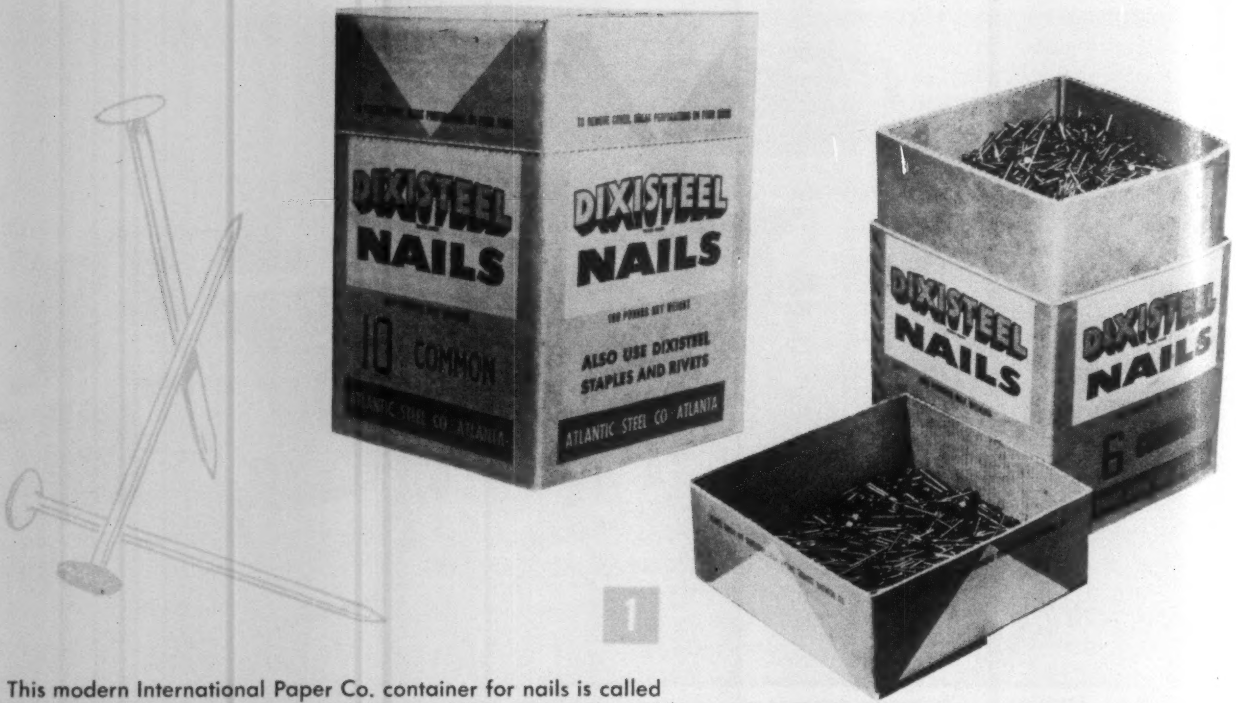
Fig. 10—Illustrated is a rubber plant system which automatically feeds predetermined quantities of 33 ingredients to a Banbury mixer at designated intervals

control such as: (1) Remote formulation in which the quantity requirements for one or more materials can be established at a distant panel board, (2) remote observation and recording of the accuracy of weighings, (3) correcting for varying tare, correcting for varying moisture, or multiplying by a price per pound with electronic computers in the recording circuitry, or (4) totalizing production for purposes of inventory control or remote supervision with electronic counters capable of counting the graduations on a dial scale as fast as a pointer goes past them.

Two specific applications are illustrated by *Figs.* 9 and 10. The layout shown in *Fig.* 9 is for 30 different screw conveyors located under their respective bins and directed to bring cattle feed ingredients to three automatic proportioning scales, which in turn discharge to three 3-ton mixers. Their operation is entirely automatic according to the formula requirements established at the master control panel. Remote dial followers indicate the performance of the feeders in relation to required material weight, and records of each material injection are made on circular charts. With certain duplication of controls, formulas can be automatically changed from one to another as required tonnages are delivered. Although there is as yet no precedent for it, formulas or weight settings can be established by punch cards feeding the necessary data to the control system.

Shown in *Fig.* 10 is the mill room in a prominent rubber plant where the complete compounding of 33 ingredients is done automatically under the supervision of a single operator in the control room. Here any of six carbon blacks, eleven oils, twelve accelerators, eight pigments, and eight grades of pellet rubber are fed to a Banbury mixer in the proper quantities and at prescribed times. Each section of the master control panel regulates the feeding of one of the groups of materials, with remote indication of the dial scale performance.

Such are some of the developments in materials handling, automatic weighing and instrumentation. As in other areas, progress in these areas is continually required in the effort to improve quality control and increase the productivity of available labor.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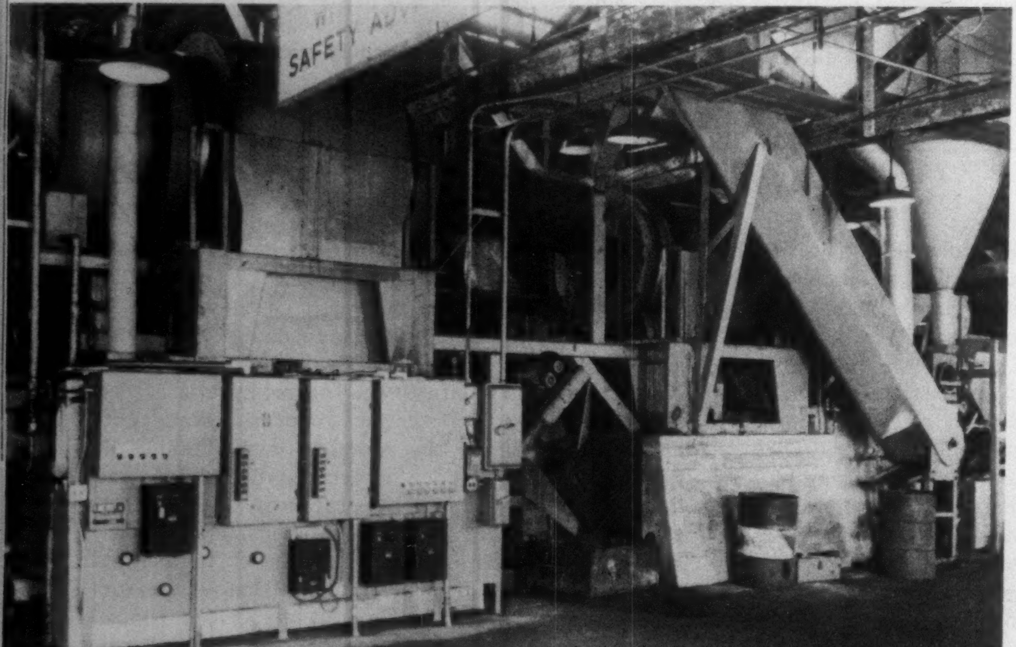
DIXISTEEL NAILS
ALSO USE DIXISTEEL STAPLES AND RIVETS
ATLANTIC STEEL CO · ATLANTA
DIXISTEEL NAILS
DIXISTEEL NAILS
6

1

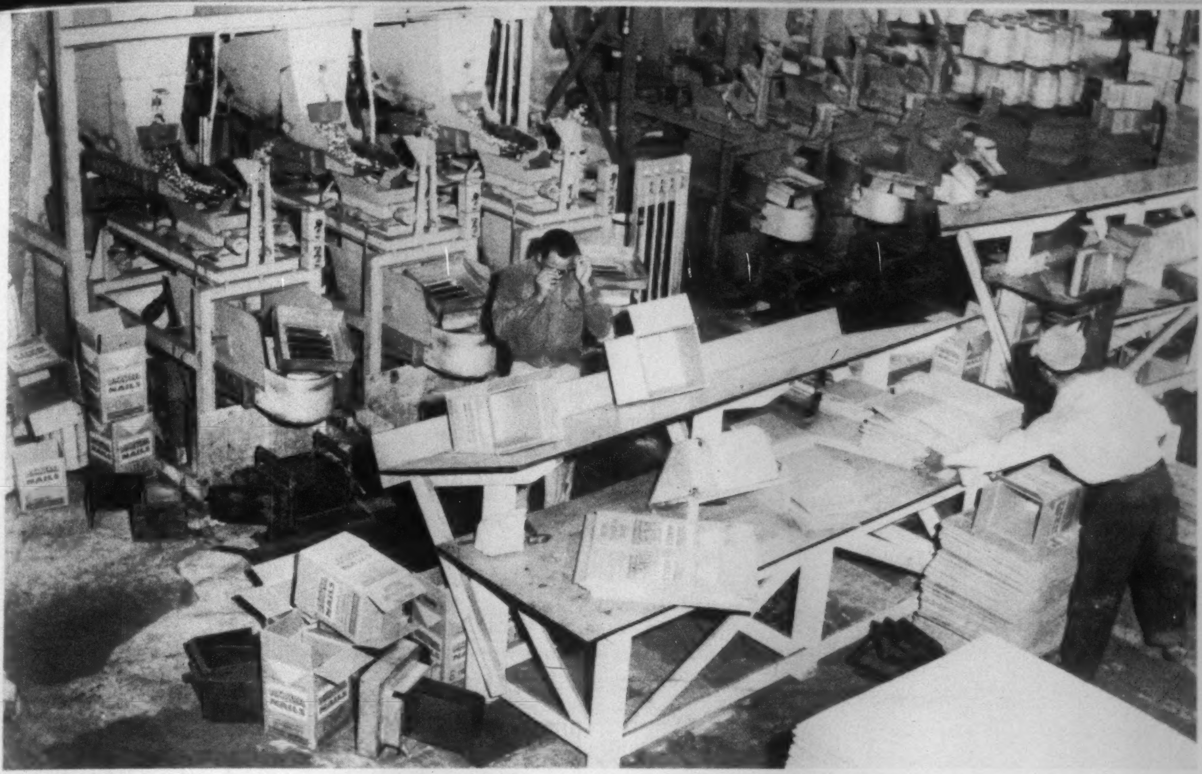
This modern International Paper Co. container for nails is called a Nail Caddy. The four sides of the outer box are perforated about four inches from the top. Direct blows on the corners and sides along the perforation scoring release the top section in the form of a cover, which slips off and can be used as a tote-box. Cover can be replaced to keep the nails clean and dry.

AUTOMATION TODAY



2

Nails are automatically cleaned in one of the two Ransohoff units, each of which can process more than 6700 pounds of nails per hour. In the hot water wet mill section whiskers left by the nail cutting knives are removed and screened out through blind screens. Nails get a partial burnished finish by rubbing against each other, and are discharged into the dry mill section where they are dried and polished by tumbling in preheated pulverized corn cob meal. Upon completion of the cycle the nails and meal are automatically emptied onto a vibrating screen. The meal is sucked into an exhauster and returned through a cyclone separator to the meal supply barrel for reuse. Nails continue into one of three weigh-feeding hoppers.



3

General view of the box making and loading stations at outlet end of cleaner. Adjustable wooden jig on table facilitates insertion of tube in sleeve and enables one man to assemble in excess of 150 boxes per hour. Floor level slat conveyor (not visible) moves filled packages off to the right.

NAIL CLEANING AND PACKAGING

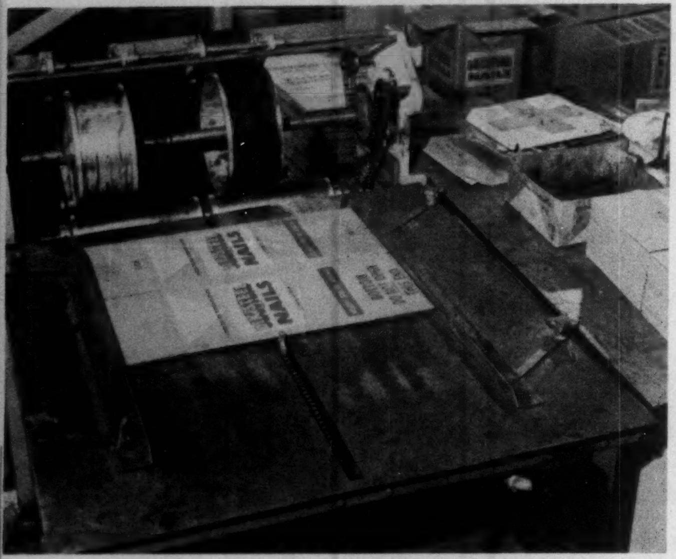
AUTOMATION ADVANCES stem from a wide variety of potential sources of improvements. A new control device, a new machining principle, a tooling development, an improved handling system, a product design change or a new packing technique might singularly be the keystone to the design of an automated system. Operating management is continually alert to progress in all functional areas of specialization, as well as in different industries, in an endeavor to apply new know-how to the tasks of reducing costs and supplying a better product.

Typical of automation developments that result from the combination of automatic operations into automatic production processes that utilize a new design of package is the nail cleaning and boxing installation at the Atlantic Steel Co. The Nail Caddy is the result of four years development and research which started in the International Paper Co.'s Georgetown Laboratory in South Carolina. Working in conjunction with the customer, this effort was to ultimately provide a package that was strong, moisture repellent, safe and convenient to handle and store. The box also yields a saving in shipping weight in comparison with the nail keg it replaces.

This box is used in a production process in which nail cleaning is accomplished in a Ransohoff unit that has a wet mill, a dry mill and a weighing operation all integrated into one continuous automatic operation. In addition to performing the cleaning operation faster and better, this unit is also credited with improving working conditions by reducing dust in the plant.

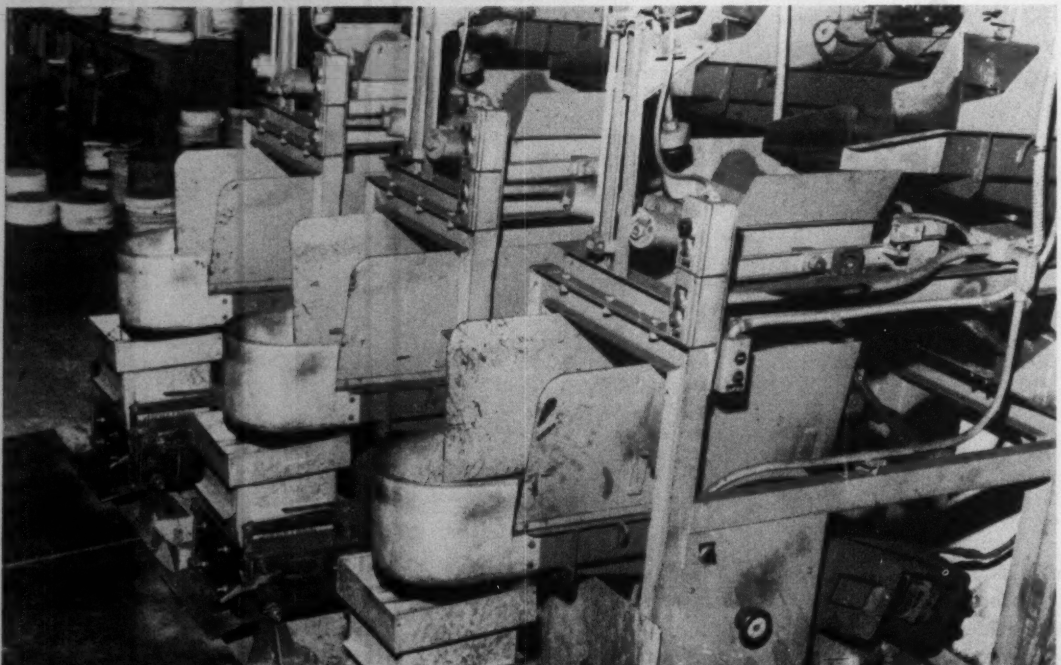
Hoppers on the outlet end of the cleaner automatically weigh and feed 100-pound lots of nails into the Caddy boxes. The filled boxes are moved by slat conveyor to the Packomatic case sealer where top and bottom are glued and closed. Box ready for shipment are delivered to the pallet loa ing station.

Nails to be blued or galvanized are handled i the same manner, shown in the accompanyin photos, except the top flaps of the boxes are hel against the sides either by a steel band or speci flap perforations. This prevents the top from bein closed and sealed at this point and enables palle loads of cleaned and boxed nails to be transporte to another department for subsequent processing.



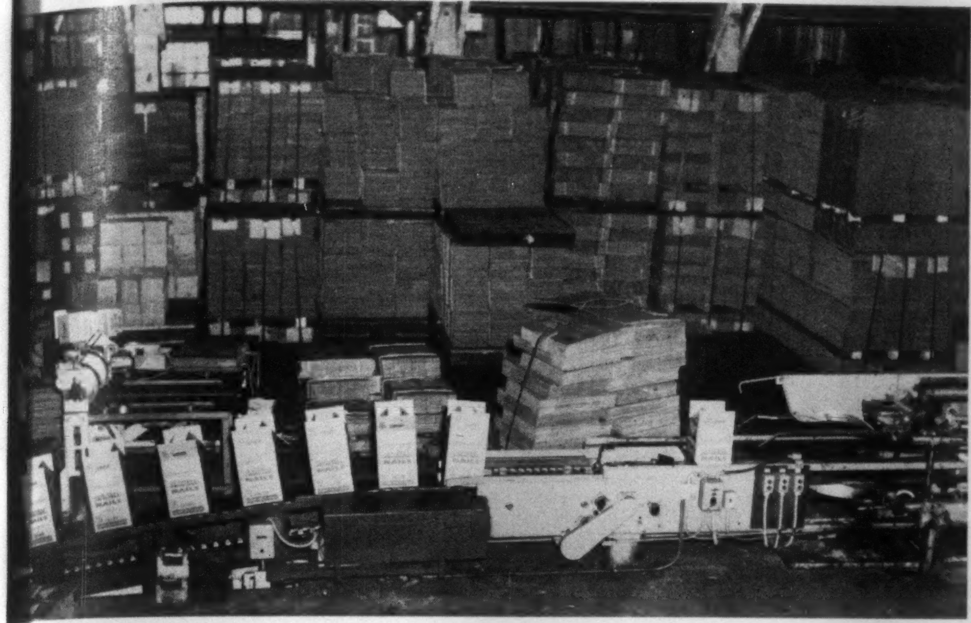
4

Industrial Marking Equipment machine prints nail size identification on two adjacent sides and a top flap of outer boxes. Adjustable position drums hold type slugs of molded rubber. Imprinting is done on schedule just prior to folding. Boxes may be imprinted at the rate of 40 per minute. Total number of boxes imprinted is figured on the basis of total batch weight cleaned minus estimated loss of weight in cleaning.



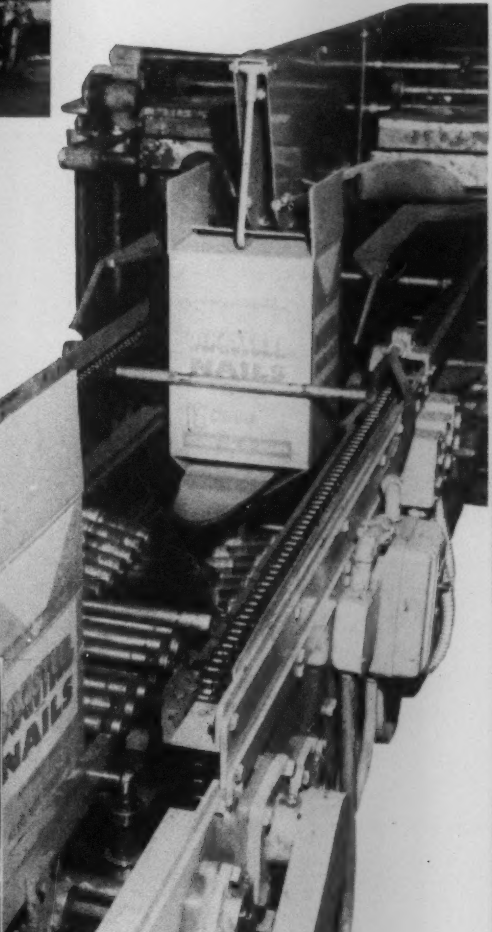
5

Boxes are placed in the shaker fixture with the filler funnel secured to the top of the box. Flanged lips on the funnel serve two purposes—first, permit easy entry into the box, spreading the flaps downward; second, the lip engages the receptacle so that there is no rocking of the funnel. Filler funnels are to be changed in design to have sloping sides (instead of the square sides shown) so that all nails will go directly into the container. Shaker has straight push-pull action—approximately ¾-inch stroke. Most sizes of nails are run at a 300 thrust per minute cycle. This speed can be adjusted by the variable voltage control. Operator pulls filled Caddys down the two degree slope to the floor level steel slat conveyor.



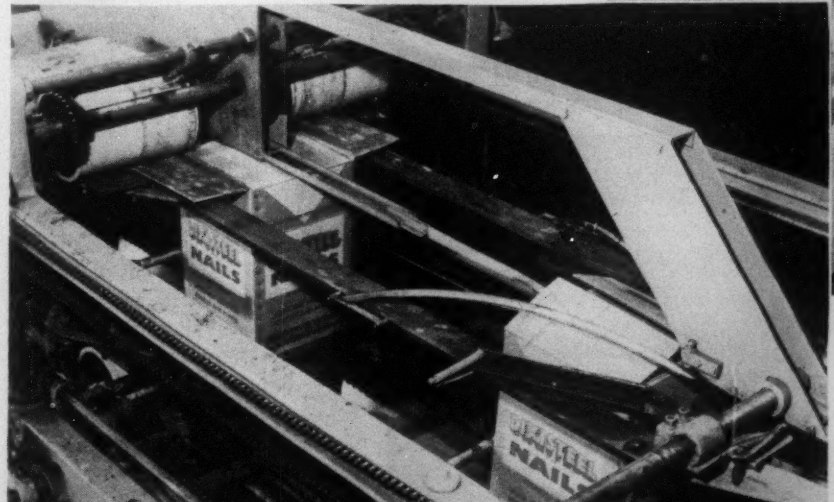
6

Filled boxes are delivered to an inclined slat conveyor that elevates them to the level of the inlet end of the Packomatic case sealing machine.



7

Close-up picture of the sealing machine shows section where boxes leave the centering device and move onto short bearing rolls placed at an incline so that bottom flaps will open slightly to allow insertion of package plate blade. Flight bars between side chains push boxes through the machine. Guides spread flaps open into position to receive glue.

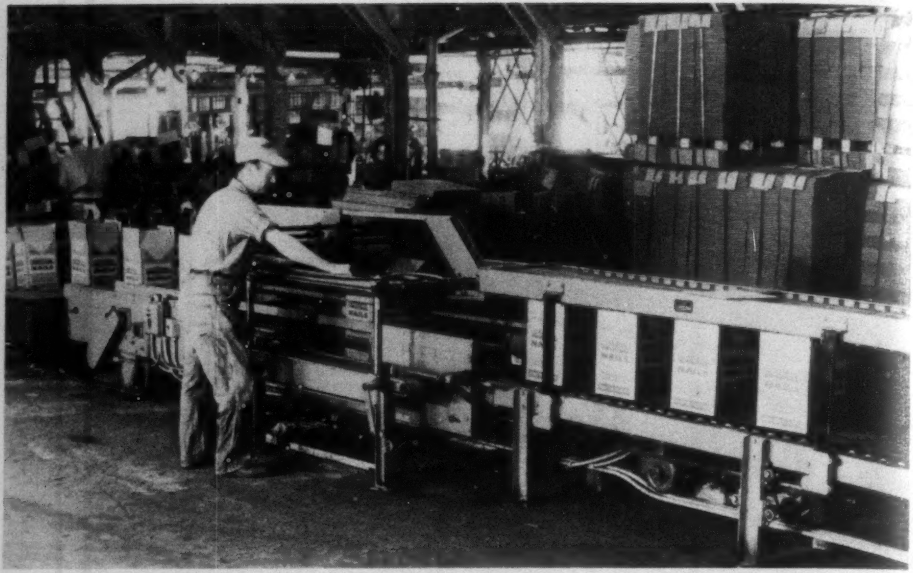


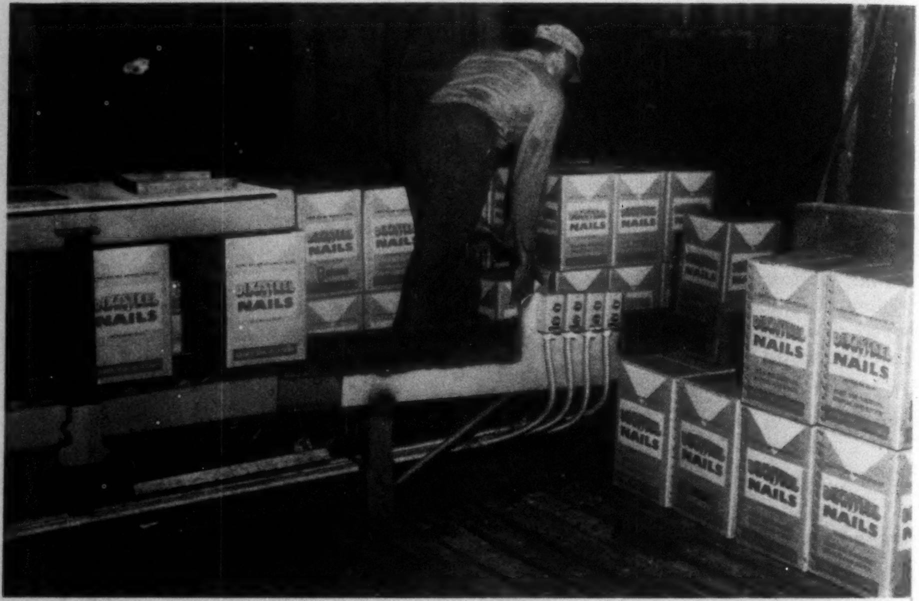
8

View at opposite end of glue section shows boxes moving to the right. Top and bottom flaps are glued simultaneously with Williamson rubber resin adhesive. Guide bars bring flaps into closed position.

9

This case sealer which operates on 11 boxes per minute delivers these boxes to an eight foot long compression section that holds the flaps closed while the glue sets.





10

Boxes are stacked on pallets in a 4 x 4 x 2 pattern as they emerge from the end of the compression unit. Controls shown operate the sealer, the two feeder conveyors and the main conveyor line.

11

Palletized Caddys are moved by fork lift trucks into the Atlantic Steel Co. warehouse area. Boxes stack neatly and take up 25 per cent less warehouse space than the wooden kegs formerly used.

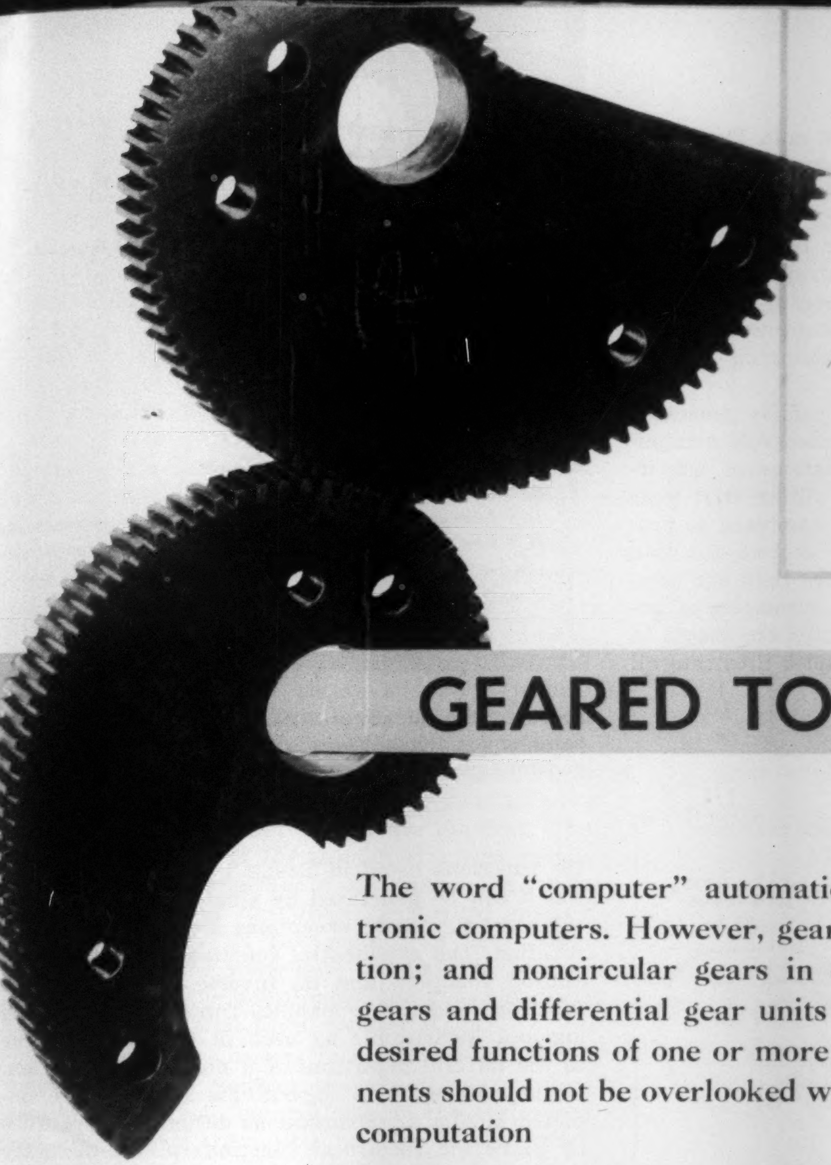


TABLE 1

Mechanization of these functions is possible with noncircular gears

1. Reciprocal
2. Exponential and its inverse, the logarithmic
3. Hyperbolic
    a. Multiplication
    b. Division
4. Powers and roots
5. Circular trigonometric
    a. Sine
    b. Cosine
    c. Tangent
6. Hyperbolic trigonometric
    a. Hyperbolic sine
    b. Hyperbolic cosine
    c. Hyperbolic tangent
7. Trigonometric functions for multiple or fractional angles
8. Log cosine
9. Sine raised to a power
10. Probability function

GEARED TO COMPUTE

The word "computer" automatically brings to mind electronic computers. However, gearing is a form of computation; and noncircular gears in combination with circular gears and differential gear units can continuously compute desired functions of one or more input values. Such components should not be overlooked when considering a means of computation

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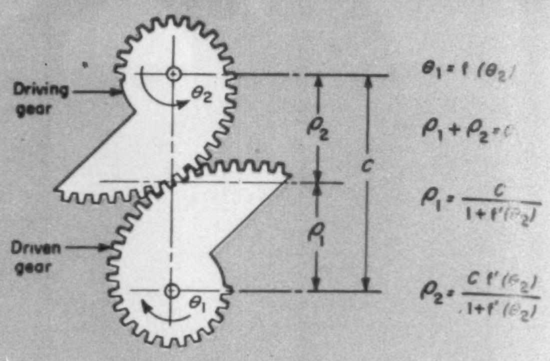
INCREASED DEMAND for rapidly computed values based on continuous data has brought about many developments in computing equipment. One of the basic areas of interest in computer design is in utilization of purely mechanical computing elements. The purpose of this article is to outline possible mechanizations of certain analytic functions by use of noncircular coplanar gears. Arrangements discussed in this article are listed in TABLE 1. Noncircular gearing arranged with suitable circular and differential gearing will generate all of the functions listed in this table and also other functions not shown.

Basic design equations for noncircular gears have been derived and are set forth in *Fig.* 1. These equations define the pitch lines of pairs of gears to produce desired rotational relationships. Specific expressions developed from the general equations are shown in TABLE 2 for many of the functions listed in TABLE 1. When design values have been assigned to the constants in these specific expressions, the radii from the centers of rotation to successive points on the pitch surfaces of the mating gears can be calculated.

Design Features

The profiles of gear pairs to mechanize some functions are shown in *Figs.* 2, 3, 4, 5 and 6 for specific values of the design constants. These sample profiles illustrate the fact that there are limitations in the range of mechanization of functions by noncircular gears. These limitations are determined by the profiles of the specific gears used. The driven gear shown in *Fig.* 2 will rotate through an angle of approximately 130 degrees. The driven gear in *Fig.* 3 will rotate through an angle of 348 degrees, while the driver will rotate through an angle of only 270 degrees. Since a zero denominator is to be avoided in the expression for the pitch line radius, functions such as the sine and cosine may be offset by a constant which



θ_1 = Angular position of the output shaft
θ_2 = Angular position of the input shaft
ρ_1 = Pitch line radius of the driven gear corresponding to angular position θ_1
ρ_2 = Pitch line radius of the driving gear corresponding to angular position θ_2
$f'(\theta_2)$ = First derivative with respect to θ_2 of the function to be mechanized
C = Distance between centers of rotation of the gears

Fig. 1—Pitch surface profiles can be defined for mated pairs of noncircular gears by expressions based on the general equations shown here

can be subtracted by a differential unit. The cosine gears, *Fig.* 4, for the same value of constant K have the same limits as the sine gears in *Fig.* 3. In the mechanization of the sine of half angles shown in *Fig.* 5 the driven gear rotates through 355 degrees but the driver rotates through only 150 degrees. The limits of rotation of noncircular gears are altered by changing the arbitrary values for the constants n and K, thus changing the profiles of the gears.

Because logarithmic functions can be generated for values of other functions, innumerable manipulations are possible with combinations of noncircular gears, circular gears and differential gear units. Several functions can be combined to produce a complex function, and a desired function can sometimes be obtained by more than one combination of component functions. Examples of arrangements for various relationships are shown in *Figs.* 7 through 18. These examples illustrate all the functions listed in TABLE 1 except three types which can be generated by single pairs of noncircular gears. These exceptions are: The reciprocal function; the exponential function, also called the antilog function, and its inverse the logarithmic function; and the probability function. The terms log and logarithmic as used in this article refer to the natural logarithm of a number or function. Gear profiles for a logarithmic function are depicted in *Fig.* 2. Expressions defining the profiles of gears for reciprocal functions and probability functions are included in TABLE 2.

TABLE 2

Desired function of θ_2 (θ_1)	Driven gear pitch radius (ρ_1)	Driving gear pitch radius (ρ_2)
$\frac{K}{\theta_2}$	$\frac{CK}{K+\theta_1^2}$	$\frac{CK}{K+\theta_2^2}$
$Ae^{\frac{\theta_2}{K}}$	$\frac{CK}{K+\theta_1}$	$\frac{CA}{Ke^{-\frac{\theta_2}{K}}+A}$
$K \log \theta_2$	$\frac{C\theta_2}{\theta_2+K}$	$\frac{CK}{\theta_2+K}$
$\sin \theta_2 + K\theta_2$	$\frac{C}{1+K+\cos \theta_2}$	$\frac{C(K+\cos \theta_2)}{1+K+\cos \theta_2}$
$\cos \theta_2 + K\theta_2$	$\frac{C}{1+K-\sin \theta_2}$	$\frac{C(K-\sin \theta_2)}{1+K-\sin \theta_2}$
$K \tan \theta_2$	$\frac{C \cos^2 \theta_2}{K+\cos^2 \theta_2}$	$\frac{CK}{K+\cos^2 \theta_2}$
$K\theta_2^n$	$\frac{C}{1+Kn\theta_2^{(n-1)}}$	$\frac{CKn\theta_2^{(n-1)}}{1+Kn\theta_2^{(n-1)}}$
$Ae^{-\frac{\theta_2^2}{K}}$	$\frac{CK}{K-2\theta_1\theta_2}$	$\frac{2C\theta_1\theta_2}{2\theta_1\theta_2-K}$
$\log \cos \theta_2 + K\theta_2$	$\frac{C}{1+K-\tan \theta_2}$	$\frac{-C(\tan \theta_2-K)}{1-\tan \theta_2+K}$
$\sin^2 \theta_2 + K\theta_2$	$\frac{C}{1+2\sin \theta_2 \cos \theta_2+K}$	$\frac{2C \sin \theta_2 \cos \theta_2+CK}{1+2\sin \theta_2 \cos \theta_2+K}$
$\sin \frac{\theta_2}{n} + K\theta_2$	$\frac{C}{1+\frac{1}{n}\cos \frac{\theta_2}{n}+K}$	$\frac{C(\frac{1}{n}\cos \frac{\theta_2}{n}+K)}{1+\frac{1}{n}\cos \frac{\theta_2}{n}+K}$

n and K are constants assigned values by the designer
Other symbols used are the same as shown in Fig. 1

▶ Production of Noncircular Gears

Until recently, there were few gear manufacturers who were prepared to generate precision noncircular gears. Some equipment made by such companies as General Electric Co., Sperry Gyroscope Co., and others, used noncircular gears, and the companies made the gears themselves.

Increasing utilization of noncircular gears has brought recent developments in their production. In co-operation with others, the Fellows Gear Shaper Co. developed shaper cutting processes for the manufacture of noncircular gears. Using a rack-type reciprocating cutter, the work must have two translatory motions and a rotation. If a circular reciprocating cutter is used, the cutter rotates and the work rotates and moves along the line formed by the center of rotation of the work and the center of rotation of the cutter. Fellows has built such devices, but they are designed to copy master gears.

Workpiece motions may be governed by a fixture which causes the work to assume the correct positions with respect to a rack-type cutter. They may also be controlled by a series of circular segments, a master cam, or an electronic device controlled in one of a number of ways. Frederick W. Cunningham of Cunningham Industries Inc. uses electronic controls for positioning the work. Frankford Arsenal has a machine in which two operators follow curves with traveling microscopes. This seems to be an application for a high gain electromechanical servomechanism, but it can be done by purely mechanical means using gears, cams, and differentials.

It is possible to grind or mill a gear and its mate, tooth by tooth. But to get theoretically correct profiles, each cutter for each space is different, and even the sides of the cutter differ. Hence, to get theoretically correct teeth in a form cutting or grinding operation, a complex process is necessary, and such a process is therefore not recommended for quantity production or high precision.

If any quantity of precise noncircular gears is required, it is possible to build a fixture which will allow the workpiece to rotate and move in two directions at the same time such that the teeth in the workpiece are generated either by a rack-type cutter or by annular rings on a grinding wheel. If the grinding method is used, a grinder of suitable size and a proper wheel dresser are required. The difficulty with use of the annular ring type grinding wheel is in spacing of the rings, but, with proper dressing of the wheel, very good spacing can be obtained. In this method of generating, the motion of the work does not have to be synchronized with the rotation of the wheel because the cutting surfaces form annular rings.

If, however, one desires to make threads on the wheel and use a hobbing process, then it is necessary to control the motions of the workpiece and synchronize them with rotation of the cutter or grinding wheel. This requires two motions if a threaded wheel is used: Rotation of work and separation of centers. The third motion is accounted for by axial advance of the thread. This process would be called hobbing or hobbing grinding.

The other motion to consider is the feed motion. In the event the work piece is thin and the cutter is of large diameter, a plunge-type cut (feeding the cutter into the work intermittently) could be used. If the work piece is too thick for this, then the feed is across the work piece as in any conventional hobbing operation. There is reason to believe that both the highest production and the greatest precision will be obtained by the hobbing grinding process even though this process, when applied to noncircular gears, is very complicated.

These latter methods of noncircular gear generation have been considered by Vinco Corp. whose experience in the field of precision ground cams and ground master gears, would permit production of noncircular gears generated by grinding to master gear tolerances.

Development of potentialities of noncircular gear devices is dependent upon awareness of their utility and availability in quantity and quality. It seems most probable that increased recognition will bring increased availability.

$$\theta_1 = K \log \theta_2$$

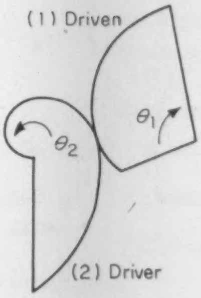


Fig. 2—Log gear profiles for the relationship shown, sketched for $K = 1.0$

$$\theta_1 = \sin\theta_2 + K\theta_2$$

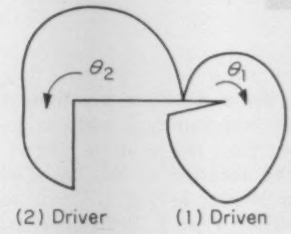


Fig. 3—Sine gear profiles for the function noted, illustrated with $K = 1.5$

$$\theta_1 = \cos\theta_2 + K\theta_2$$

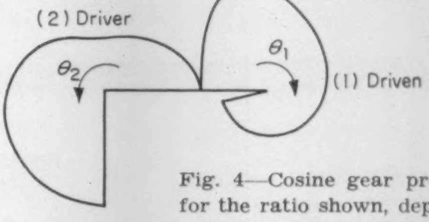


Fig. 4—Cosine gear profiles for the ratio shown, depicted with $K = 1.5$

$$\theta_1 = \sin\frac{\theta_2}{n} + K\theta_2$$

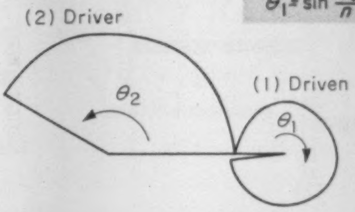


Fig. 5—Gear profiles for the sine of multiple or fractional angles illustrated for $K = 2.0$ and $n = 2.0$

$$\theta_1 = \underline{\sin}^n\theta_2 + K\theta_2$$

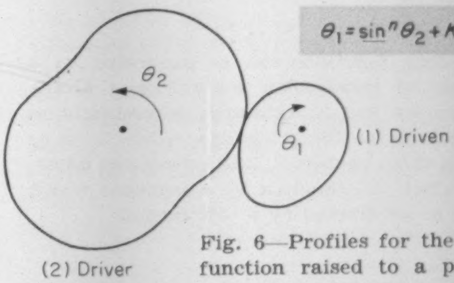


Fig. 6—Profiles for the sine function raised to a power with $K = 2.0$ and $n = 2.0$

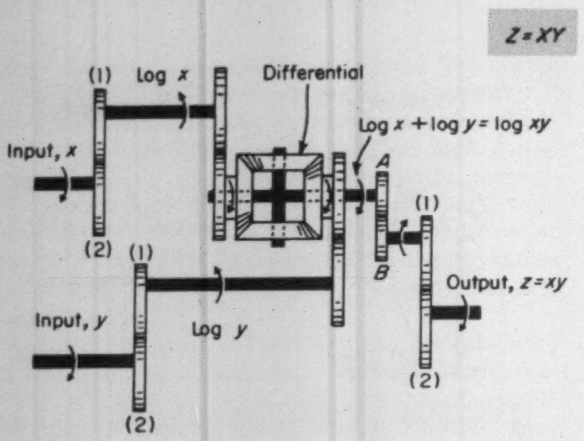
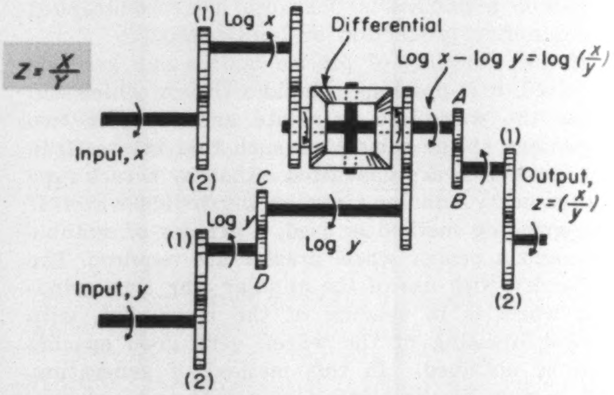

Z=XY
(1)
Log x
Differential
Log x + log y = log xy
Input, x
A
(1)
(2)
(1)
B
Output, z=xy
Input, y
Log y
(2)
(2)

Fig. 7—Multiplication, a hyperbolic function of the form $z = xy$, may be performed as shown. Gears marked 1 and 2 correspond respectively to log gears 1 and 2 shown in profile in *Fig.* 2. Inputs x and y are converted to log x and log y by separate pairs of these log gears. The outputs of these two pairs of log gears are added by a differential. The sum, log x + log y = log xy, is then fed into an antilog unit. This unit consists of two identical circular gears, *A* and *B*, and another set of logarithmic gears. Gear 1 is now the driver and gear 2 is the driven. Thus the antilog of the differential output is obtained and log x + log y = log xy becomes $z = xy$

Fig. 8—Mechanization of a function involving division is the same as for a function involving multiplication except that two identical circular gears, *C* and *D*, are inserted into the system. These circular gears reverse the rotation of the log y shaft. The differential then subtracts log y from log x instead of adding it as in *Fig.* 7. Division could be handled in exactly the same manner as multiplication if the log of the reciprocal of the denominator were added to the log of the numerator and the antilog of the sum of the two logs taken


$Z = \frac{X}{Y}$
(1)
Log x
Differential
Log x − log y = log ($\frac{x}{y}$)
A
(1)
Input, x
(2)
C
Output, z=($\frac{x}{y}$)
B
Log y
(1)
Log y
D
Input, y
(2)
(2)

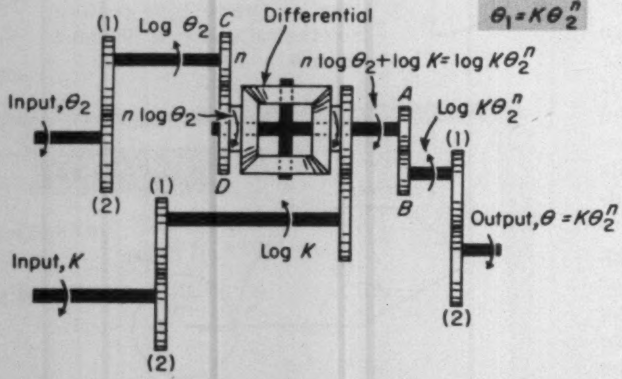
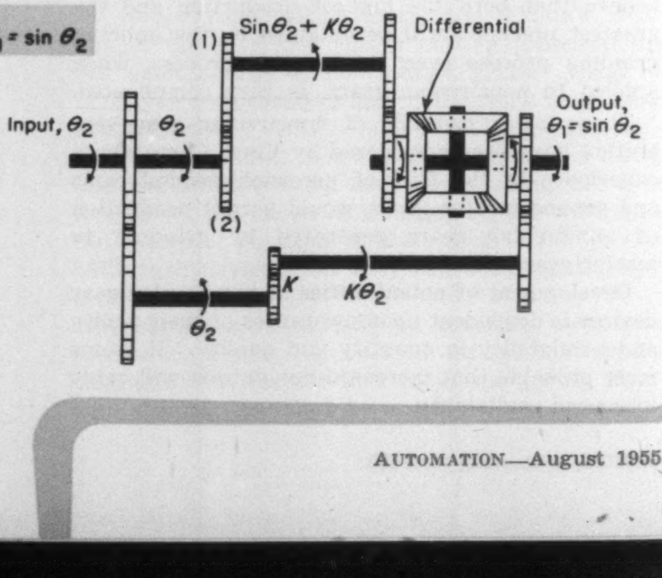

$\theta_1 = K\theta_2^n$
(1)
Log θ_2
C
Differential
n
n log θ_2 + log K = log $K\theta_2^n$
Input, θ_2
n log θ_2
A
Log $K\theta_2^n$
(1)
(2)
(1)
D
B
Output, $\theta = K\theta_2^n$
Log K
Input, K
(2)
(2)

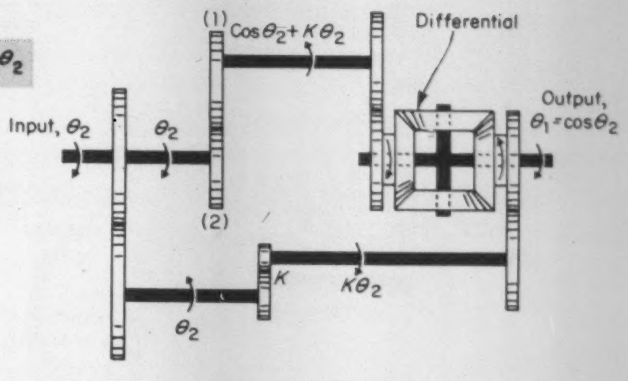
Fig. 9—Mechanization of power and root problems is the same as that for multiplication, with one exception. Circular gears *C* and *D* are varied so that their gear ratio corresponds to exponent n. Converting inputs to logs, adding these logs with a differential and getting the antilog are processes identical with the procedure illustrated in *Fig.* 7. Mechanizing $z = x^2$ consists of taking the log of x and varying gears *C* and *D* so that they multiply the log of x by 2, or n. The antilog of the product is x^2. If the exponent is a fraction, for example 5/2, the root is found by making the ratio of the circular gears, *C* and *D*, 5/2 instead of 2 as in the previous case

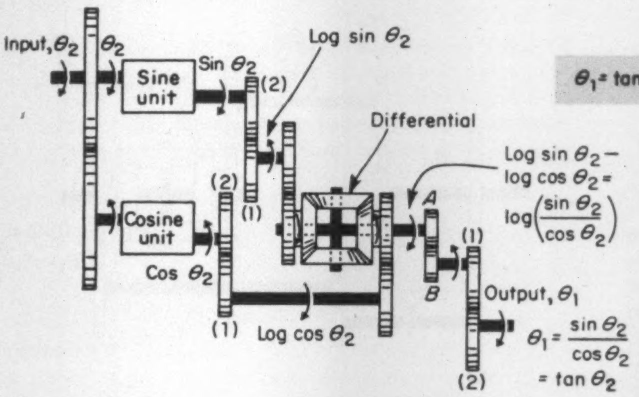
Fig. 10—Sine functions can be generated by a single pair of noncircular gears. For a profile illustration see *Fig.* 3. As a zero denominator in the expression for the pitch line radius is to be avoided in these problems, it is sometimes advisable to offset the function by a constant which later can be subtracted by a differential


$\theta_1 = \sin\theta_2$
(1)
Sinθ_2 + Kθ_2
Differential
Output, $\theta_1 = \sin\theta_2$
Input, θ_2
θ_2
(2)
K
Kθ_2
θ_2

$\theta_1 = \cos\theta_2$

Fig. 11—Cosine functions can also be generated by a single pair of noncircular gears. Cosine profiles for a selected design value are depicted in *Fig.* 4. Here too, a constant offset is used and later removed


(1)
$\cos\theta_2 + K\theta_2$
Differential
Input, θ_2
θ_2
Output, $\theta_1 = \cos\theta_2$
(2)
K
$K\theta_2$
θ_2


Input, θ_2
θ_2
Log sin θ_2
Sine unit
Sin θ_2
(2)
Differential
Log sin θ_2 − log cos θ_2 = log$\left(\frac{\sin\theta_2}{\cos\theta_2}\right)$
(2)
(1)
A
Cosine unit
Cos θ_2
(1)
B
Output, θ_1
(1)
Log cos θ_2
$\theta_1 = \frac{\sin\theta_2}{\cos\theta_2} = \tan\theta_2$
(2)

$\theta_1 = \tan\theta_2$

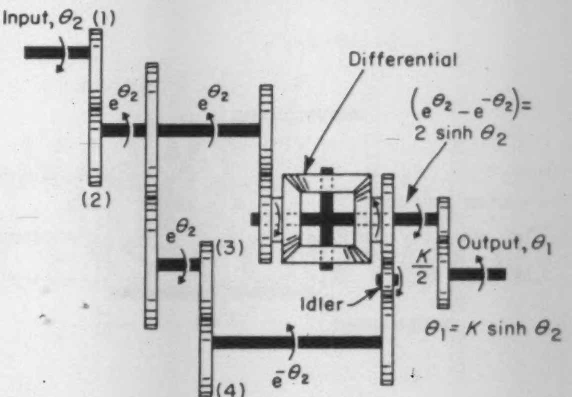
Fig. 12—An option may be exercised in mechanizing the tangent function. As indicated by the expressions given in TABLE 2, a single pair of gears, not illustrated in this article, can be used. In the event of a large θ_2, the formula $\tan\theta_2 = (\sin\theta_2)/(\cos\theta_2)$ is used and the logarithm process is employed with sine and cosine units

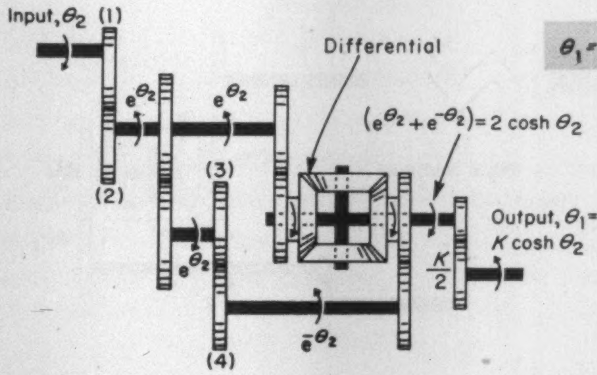
$\theta_1 = K \sinh\theta_2$

Fig. 13—In mechanizing the hyperbolic sine function, the formula used is

$$\sinh\theta_2 = \frac{1}{2}\left(e^{\theta_2} - e^{-\theta_2}\right)$$

The input is first converted to its equivalent in terms of exponentials by the use of log gears which have had input and output reversed. Gears marked 3 and 4 are reciprocal gears. The exponentials are subtracted by the differential and the output passes through a pair of circular gears whose ratio is $K/2$


Input, θ_2 (1)
Differential
e^{θ_2}
e^{θ_2}
$\left(e^{\theta_2} - e^{-\theta_2}\right) = 2\sinh\theta_2$
(2)
e^{θ_2}
(3)
Output, θ_1
$\frac{K}{2}$
Idler
$\theta_1 = K\sinh\theta_2$
(4)
$e^{-\theta_2}$

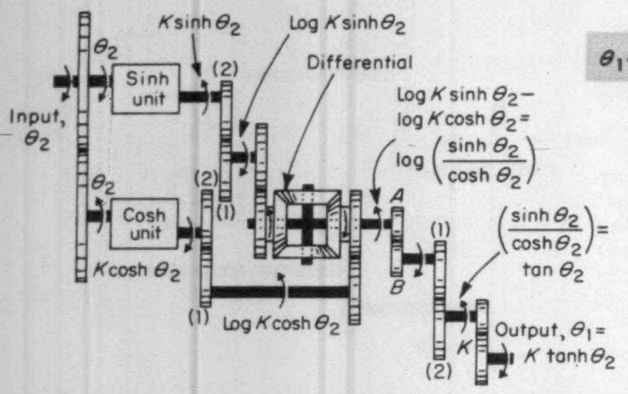

Input, θ_2 (1)
Differential
e^{θ_2}
e^{θ_2}
$\left(e^{\theta_2} + e^{-\theta_2}\right) = 2\cosh\theta_2$
(2)
(3)
Output, $\theta_1 = K\cosh\theta_2$
e^{θ_2}
$\frac{K}{2}$
(4)
$e^{-\theta_2}$

$\theta_1 = K \cosh\theta_2$

Fig. 14—The hyperbolic cosine function may be generated using the formula

$$\cosh\theta_2 = \frac{1}{2}\left(e^{\theta^2} + e^{-\theta^2}\right)$$

The gearing required is identical with that for $\sinh\theta_2$ except that the idler is removed and the exponentials are added rather than subtracted

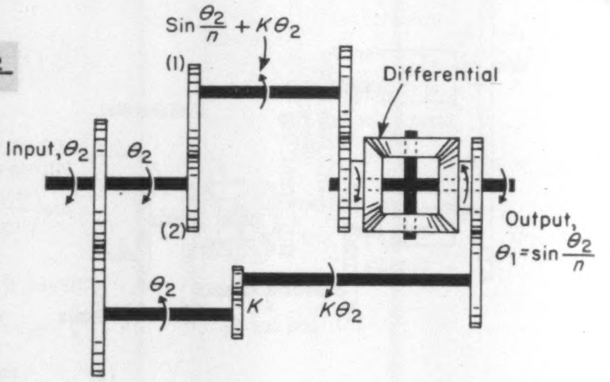

Input, $-\theta_2$
θ_2
Sinh unit
$K\sinh\theta_2$
Log $K\sinh\theta_2$
(2)
Differential
Log $K\sinh\theta_2$ − log $K\cosh\theta_2$ = log $\left(\frac{\sinh\theta_2}{\cosh\theta_2}\right)$
θ_2
(2)
Cosh unit
(1)
$K\cosh\theta_2$
A
(1)
$\left(\frac{\sinh\theta_2}{\cosh\theta_2}\right)$ = tan θ_2
B
(1)
Log $K\cosh\theta_2$
K
Output, θ_1 = $K\tanh\theta_2$
(2)

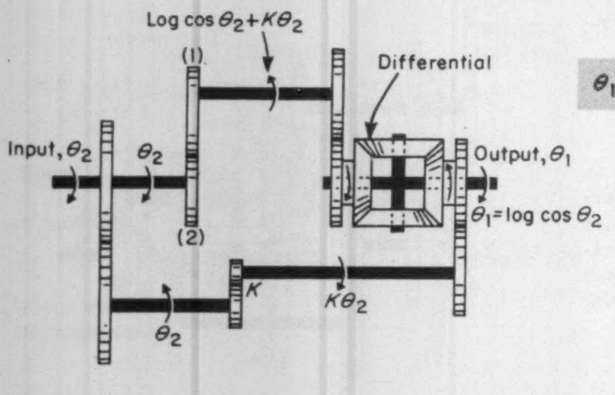
$\theta_1 = K \tanh \theta_2$

Fig. 15—By the formula tanh θ_2 = (sinh θ_2 (cosh θ_2) the hyperbolic tangent may be mech anized. Logarithm is generated for output of cosh unit and is subtracted from the generate logarithm of a sinh unit by a differential. A antilog unit consisting of a pair of identical cir cular gears, *A* and *B*, and a reversed pair o log gears, 1 and 2, converts the log function t the desired output

$\theta_1 = \sin \frac{\theta_2}{n}$

Fig. 16—Trigonometric functions of multiple or fractional angles are mechanized as shown. Only one pair of noncircular gears, 1 and 2, is used to generate such functions. This function was offset by $K\theta_2$ to avoid a zero denominator in the pitch line profile expression. The constant was then subtracted by the differential. Pitch line profiles of this function, with *n* and *K* equal to 2, are shown in *Fig.* 5


Sin $\frac{\theta_2}{n}$ + $K\theta_2$
(1)
Differential
Input, θ_2
θ_2
(2)
Output, θ_1 = sin $\frac{\theta_2}{n}$
θ_2
K
$K\theta_2$

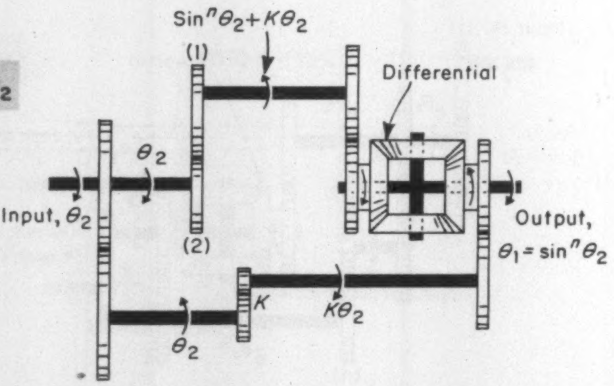

Log cos θ_2+$K\theta_2$
(1)
Differential
Input, θ_2
θ_2
(2)
Output, θ_1
θ_1=log cos θ_2
K
$K\theta_2$
θ_2

$\theta_1 = \log \cos \theta_2$

Fig. 17—Log of a trigonometric function such as the cosine can be generated using a single pair of noncircular gears, 1 and 2, as shown. This function might also be mechanized by use of a pair of log gears on the output of a cosine unit similar to *Fig.* 11

$\theta_1 = \sin^n \theta_2$

Fig. 18—Mechanization of a sine function raised to a power is implemented by a pair of gears, 1 and 2, for which profiles are shown in *Fig.* 6, where *n* and *K* each have the arbitrary value of 2. The function was offset by a constant in obtaining these profiles, and the constant expression is subtracted by the differential


Sin$^n\theta_2$+$K\theta_2$
(1)
Differential
θ_2
Input, θ_2
(2)
Output, θ_1 = sin$^n\theta_2$
K
$K\theta_2$
θ_2

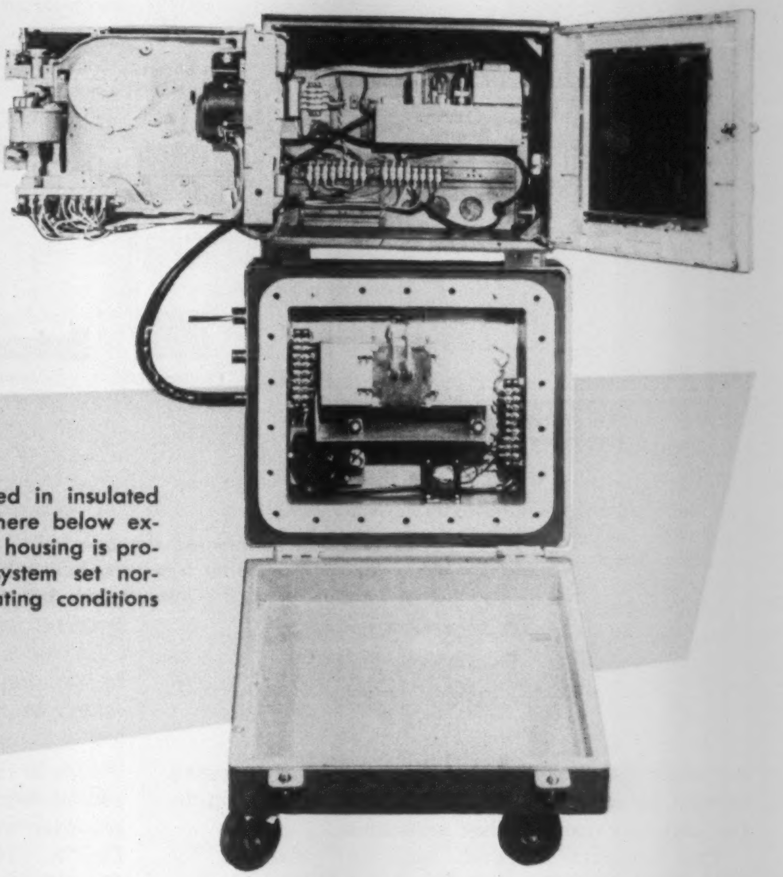


Fig. 1—Infrared analyzer is housed in insulated explosion-proof enclosure shown here below exposed recorder unit. The detector housing is provided with temperature control system set normally at 150F for optimum operating conditions

CONTINUOUS ANALYZER IMPROVES PROCESS CONTROL

Recording infrared analyzer is an answer to industry's quest for a versatile, stable and accurate processing instrument capable of performing continuous laboratory-type quantitative analyses of a flowing plant stream

USE of purity or concentration of a product as a governing factor in process control of stream flow is an important concept to the advancement of processing in the chemical industries. In analyzing gas or liquid mixtures, infrared rays are a proved, sensitive laboratory tool. The use of this laboratory technique has been refined—providing production operations with a method of continuous analysis for timely and effective control.

Infrared analysis is based upon the phenomenon of unique infrared absorption exhibited by most compounds. The wide range of theoretical application is apparent when it is considered that the only substances which do not absorb infrared are oxygen, nitrogen, hydrogen, chlorine, hydrogen sulfide, helium and the other rare gases. All other substances exhibit a unique infrared absorption pattern. Quantitative analysis is possible since

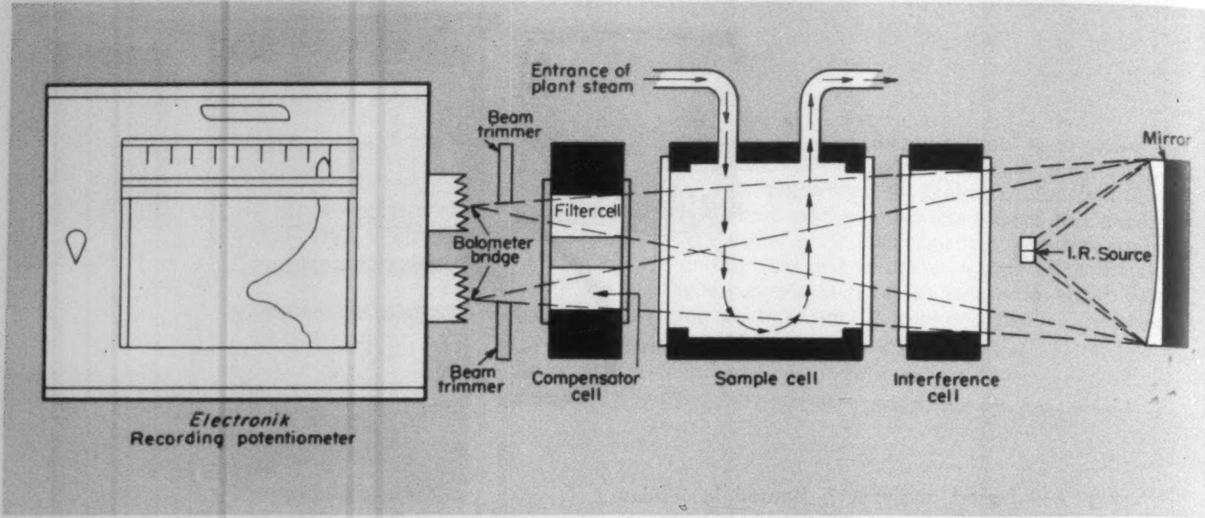


Fig. 2—Schematic diagram of infrared detector unit. Assembled unit is approximately 12 inches long. The beam trimmers, adjustable from top of the optical assembly, permit equalizing of the intensity of radiation on bolometers

the absorption of certain wavelengths of infrared energy by a given substance is in proportion to the concentration of that substance.

The selective infrared analyzer produced by Process Control Div. of Baird Associates Inc., is a nondispersive type spectrophotometer. This type of instrument works with all of the energy from the infrared source as opposed to the dispersive type which works with essentially a single wavelength in the infrared spectrum. For effective plant employment a composite assembly comprising a recorder, voltage regulator and an analyzer is used, *Fig.* 1. The recorder, supplied by the Industrial Div. of Minneapolis-Honeywell Regulator Co., can be used at the point of measurement or as far as 1200 feet from the detector. This recorder, either a circular chart, strip chart or miniature type, is supplied with a special high gain (40 ×) ampli-

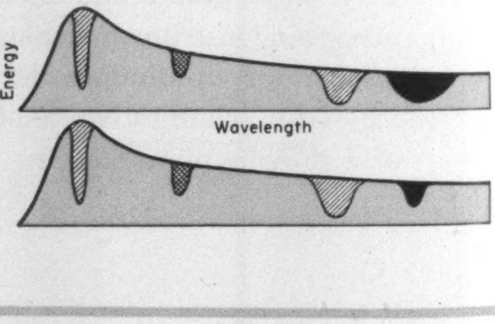


Fig. 3—Nonselective detector analyzer measures the energy of the infrared beam reduced by an amount equal to the absorption by various substances in cells of instrument. Curves to right schematically indicate total energy received at each bolometer element after passing through cells. In sensitized unit, top beam causes (for illustrative purposes) reading of 100 per cent—indicating instrument corrected for energy absorbed by pure gas *A* in filter cell. Lower beam causes reading of 5 per cent indicating smaller amount energy absorbed by gas *A* in sample cell. Note that absorption by pure gas overshadows absorption of energy in top beam as it passes through smaller concentration in sample cell. With more than one absorbing gas present in sample cell, both bolometers receive less radiation by same amount which of itself creates no electrical imbalance in modified Wheatstone bridge circuit. As before instrument reflects only imbalance caused by difference of absorption at special wavelength of gas in filter cell and sample cell. With interfering gases, instrument is compensated by use of filter action of gas in interference cell to eliminate variations at specific interfering wavelengths; reading depends on differential absorption at noninterfering wavelengths to give a measure of relative concentration of gas being sampled

fier. The detector unit is housed in an insulated box provided with an electric heater to maintain a 150 F temperature within the enclosure. A schematic of the detector unit is shown in *Fig.* 2. It consists of an infrared source, interference cell, sample cell, filter and compensator cell, beam trimmers and a bolometer assembly.

▶ Operating Details

In operation, infrared energy from the source—a small coil of nichrome wire heated to a temperature of 900 C—is focused by a conical mirror into two identical beams. These two beams are made to pass through the several cells of the unit by separate paths and are then focused on two heat-sensing elements of the bolometer assembly. This sensing unit is an adaptation of a Wheatstone bridge so constructed that the bridge will go out of balance when the resistance of one bolometer changes due to a shift in its temperature caused by the amount of heat energy received from the infrared source. This imbalance, when it occurs, provides a basis for determining the relative quantity of a substance in the plant stream. In more detail, operation of the analyzer might best be explained by reference to *Fig.* 3.

Electrical imbalance could be a measure of gas concentration but experience has shown that stability of operations is increased if the bridge always is operated from an electrically balanced position, *Fig.* 4. In practice, the substance concentration is indicated on the recorder by the distance a slide arm of a potentiometer is moved in automatically bringing the bridge back to a balanced condition after any imbalance occurs.

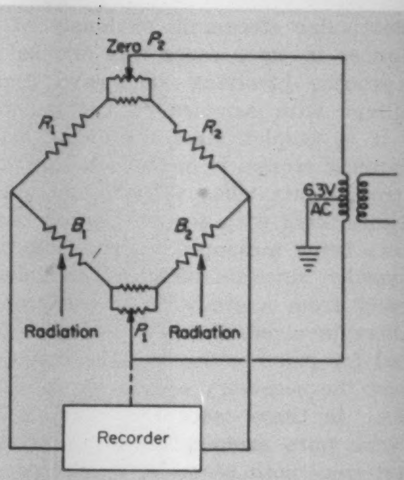
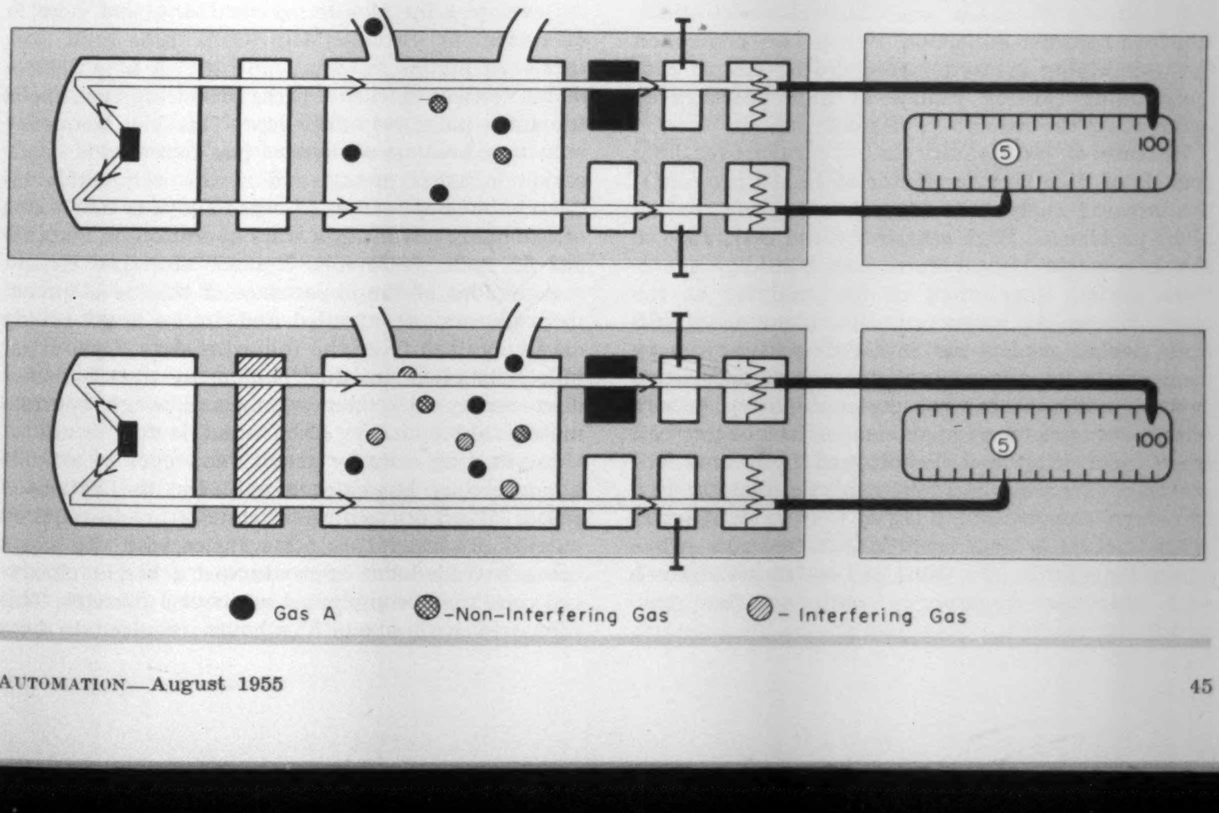


Fig. 4—Schematic of the bolometer bridge circuit. Bridge is in balance when $R_1/R_2 = B_1/B_2$. Potentiometer P_2 is manually adjusted to zero instrument. Distance slide arm of potentiometer P_1 is moved by recorder in rebalancing an unbalanced condition is an indication of gas concentration

It is necessary to know before hand what substance is to be measured; what other substances will be found with the compound being measured; and the relative range of concentrations involved. The sensitizing and calibration of the instrument



to a particular stream is obviously of the first importance; in some cases this can be a complicated process involving successive revisions of cell fillings with samples of the substances involved if a complex stream is being sampled.

A complex stream is one which contains one or more components whose absorption band for infrared interferes with the absorption band of the substance being measured. Limitations may arise but normally, since interference problems are easy to predict from a study of spectrograms of the substances involved, the interference can be compensated for prior to use and the instrument still will have the necessary sensitivity for the desired analysis. In these cases the interference cell is filled with pure samples of the interfering components; since both beams of energy pass through the interference cell both bolometers receive less energy by the same amount so far as absorption at the interfering wavelength is concerned. The instrument then records only the relative difference in absorption of energy at non-interfering wavelength between 100 per cent sample in the filter cell and the component being measured in the sample cell. Thus it is seen that quantitative isolation of the desired component is obtained by sensitizing the analyzer to changes in the concentration of the desired component by greatly reducing or eliminating its responsiveness to changes in the concentration of all other infrared absorbers present in the sample stream.

▶ Application to Liquids

The gas analyzer can be converted to a liquid analyzer by an exchange of certain cells. The theory of operation and the electronic functioning of the liquid instrument are identical with the gas instrument. However, on liquid applications one of the most important considerations is to maintain the sample completely in liquid phase within the sample cell since gas bubbles would cause spurious recorder deflection. Bubbles are controlled by maintaining a low temperature of sample cell, maintaining flowing sample at high pressure or pretreating the sample by degasifying.

Because of its stability and accuracy over long periods of time (service factor 95 to 100 per cent), the infrared analyzer is adaptable to many routine plant problems. High sensitivity and resistance to shock, adverse temperature, and humidity conditions permit installation of the analyzer at the most convenient location in the plant. Applications where continuous infrared analyzers have been employed advantageously include separation control, synthesis control, cost accounting (where billing data are based upon composition or purity), trace monitoring and blending of fuels and feed streams. Where laboratory analysis alone is used to control composition, a lag of four to eight hours behind actual process conditions is common—when compared to this, the value of continuous analysis with laboratory accuracy to continuous flow processing is evident.

INDUCTION HEATING

SPEEDS BILLET PREPARATION

SOMETIMES automation can be achieved by implementing existing facilities with automatic attachments; sometimes a new and different basic process supplies the key to automated production. Here we have an example of the latter—low frequency induction heating replacing oil-fired furnaces for billet heating of brass alloys.

Developed by Magnethermic Corp. and now in operation at Scovill Mfg. Co.'s tube mill, the three-cell unit is automatically cycled to a Schloemann vertical extrusion press producing tube shells for subsequent cold-drawing. This low frequency induction heating equipment has found wide application in other metals and in the automotive industry, but application to brass alloys is new. One of the many advantages is its operation on a standard 60 cycle, 2300 volt, 3 phase electrical circuit.

Some idea of the importance of this development to producers of extruded and drawn brass tubing may be gained from the following data. Cylindrical billets handled in this equipment are 7 inches diameter by 11½ inches long and weigh approximately 140 pounds. Each billet is fed to one of three heating cells by gravity conveyor to provide a continuous hot-billet supply for the extrusion press. Heating from room temperature to required extrusion temperature (this varies with the alloys being extruded but approximates a bright cherry-red color) is accomplished in about 4 minutes. This compares with about 3½ hours required to heat

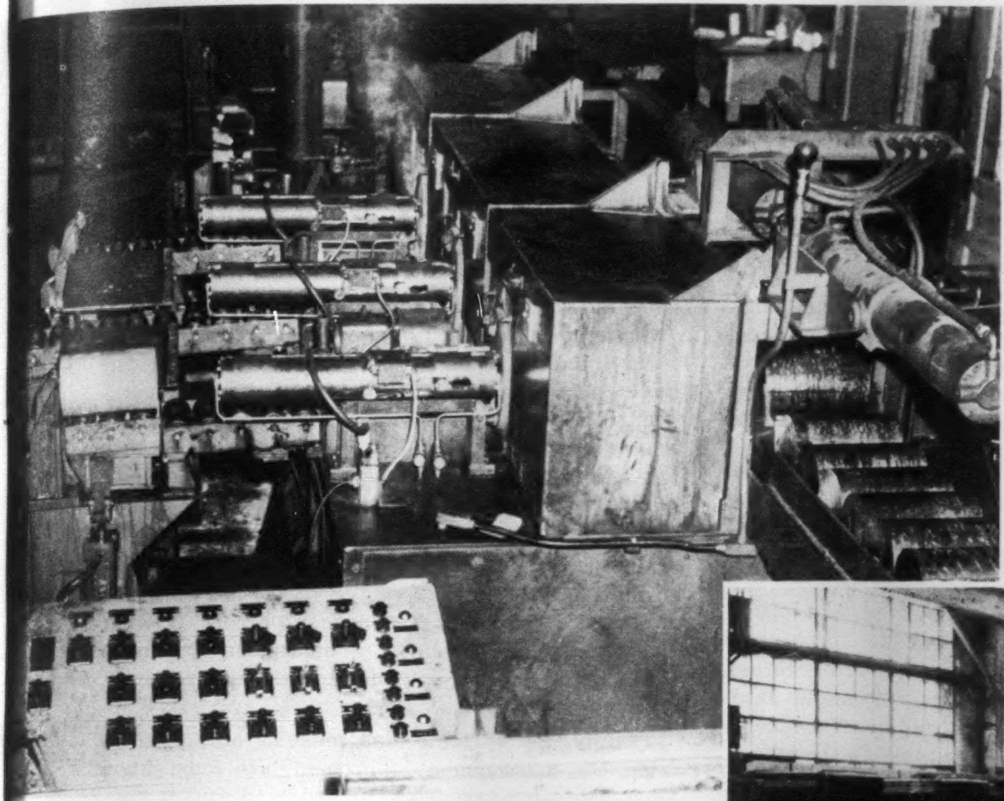


Fig. 1—Cold billets are fed to the heating unit by the conveyor on the right, while a cherry-red billet has just emerged from the front cell. Ejection mechanism cylinders are offset to the side of each exit port

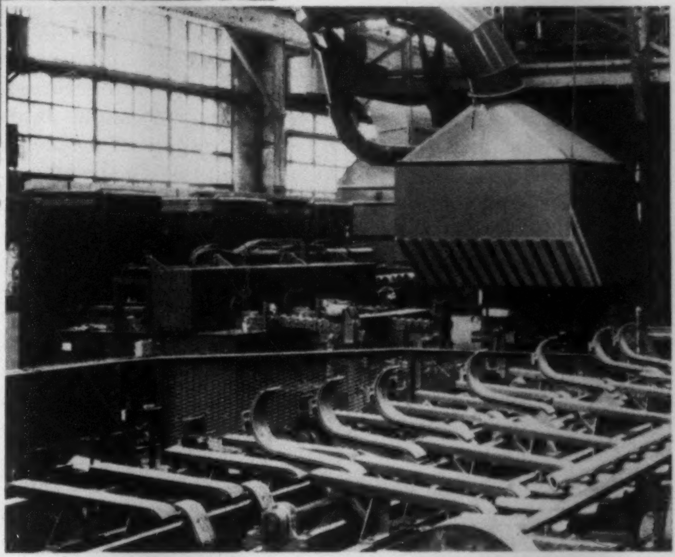


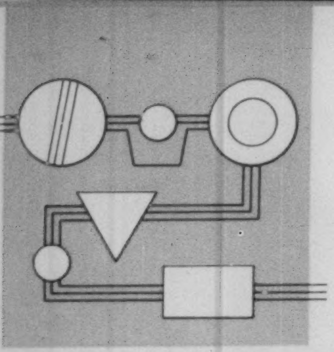
Fig. 2—Three-cell induction heating unit in the Mill Products Division of Scovill Mfg. Co. The exit side of the heating unit is shown, including a short conveyor system to feed billets toward the extrusion press. Tube handling equipment is in the foreground

similar billets in previously used oil-fired furnaces.

The oil-fired billet heating furnace feeding this press was approximately 10 feet wide by 40 feet long; feed from furnace to press was manual. By comparison, size of the three-cell induction heater unit is approximately 7 feet 6 inches wide, 6 feet high, and 11 feet long. Even with its electronic control equipment cabinets, it occupies about one-half the space of the old furnace. Equally important is the vast improvement in working conditions with far less heat lost through radiation and completely automatic handling and feeding of the heated billets to the extrusion press. At the start of the day's work, heater and press can be in full operation in minutes.

Precision in control is the other noteworthy improvement with this new method. As has been mentioned, the equipment is used in the extrusion of various copper and brass alloys. Each requires a different extrusion temperature in the billets and these temperatures are a controlling factor in the uniformity and quality of the finished cold-drawn tubing. Under previous conditions with the oil-fired furnace, good operators might hold the temperature of billets entering the press within ±15C. The induction heaters are controlled to hold temperatures within ±8C in regular production. Furthermore, when changing from extrusion of one alloy to another, the induction billet heaters permit rapid change in heating temperature without the inevitable delays with the oil-fired furnace and without losing control of temperature during the change.

The three-cell billet heater used in this brass industry installation has a capacity of approximately 6500 pounds per hour, feeding the extrusion press continuously on approximately a $1\frac{1}{2}$-minute cycle.



DATA PROCESSING
BEGINS AT HOME

By MILTON STONE
Business Systems Engineer
ElectroData Corp.
Pasadena, Calif.

EVERY DATA PROCESSING program must be built around a system adapting the capabilities of available data processing equipment to the data handling requirements of the individual company. The job of doing this falls to the systems man, appointed by management to work out a framework of procedures establishing the routine process of running the company. This framework is designed to systematize all operations except the few reserved for individual decision as prerogatives of management.

It is obvious then that this systems man must be expert in two fields—that of data processing techniques and that of his own company operation. He must have enough basic knowledge about data-processing machines to be able to think of problems in terms of processor requirements. With the advent of electronic techniques this might include feeding information into a computer in several different ways, juggling it back and forth by giving instructions to the machine, and coming up with answers in the output form desired. However, when dealing with a mechanical or electronic data processing device the intimate details of company operation must be known. The machine must be given instructions for everything it does because it cannot think.

Data processing requires a systems man to think in three ways. (1) He should be able to think imaginatively. (2) He should be able to think in terms of human relations. (3) He should be able to think in terms of management.

Imagination is necessary to be able to apply equipment such as a computer to various fields of activity. Inventory management, warehousing, distribution, marketing, product mixing or diversification setups, pricing structures, financial policy, machine loading and scheduling, even company organization (if we can reduce human abilities and characteristics to coded terms), are only a few of the activities which require imaginative thinking. Without this, returns from an investment in data processing equipment are limited to the routine of prosaic application.

Fear must be countered from a human relations standpoint. Even if electronic data processing will save thousands of dollars, it probably is not a wise investment if it adversely affects the morale of company personnel. The systems man must approach the field with some care in that direction. A good indication of human-relations thinking is found in the solution expressed by a consultant working with a large organization in New York, "with respect to the human-relations approach, we have found that there is a need to counter the feeling of job insecurity by permitting normal turnover to absorb manpower savings. This permits management to provide clerical employees with meaningful assurances against layoffs occasioned by electronic data processing."

Another aspect of human relations is that of training. In an automatic system, erroneous information once entered will be perpetuated. Boners cannot be picked up by another person, as when the work is done manually. The utmost effort must be made to train personnel in absolute accuracy when making original entries.

Finally, the systems man must be able to think from the management approach. He must know what management needs in order to run a company—what figures, information, and controls are required. These figures are useless unless they are timely. If the systems man is not capable of discernment he may find that he has created a monster which spews out figures concealing facts rather than illuminating them.

Companies have approached computer manufacturers to get into electronic data processing because they were afraid that someone else would get a jump on them. "Come on down and spend a couple of hours with us and we'll dope out some hot applications and sell management" is a too common request. Doping out some hot applications takes many months—time which the systems man should be spending and not the computer manufacturer. Although he can give expert advice on data processing methods, the computer manufacturer is not familiar with individual company details.

Here then is the challenge and the opportunity to the systems man:

1. Use data processing tools wisely and with discrimination.
2. Know their capabilities.
3. Understand that they are more than cost-cutting tools.

Properly used, data processors can aid management by illuminating trends, highlighting strong points and deficiencies. The systems man responsible for increasing use of this equipment becomes a correspondingly more important member of management.

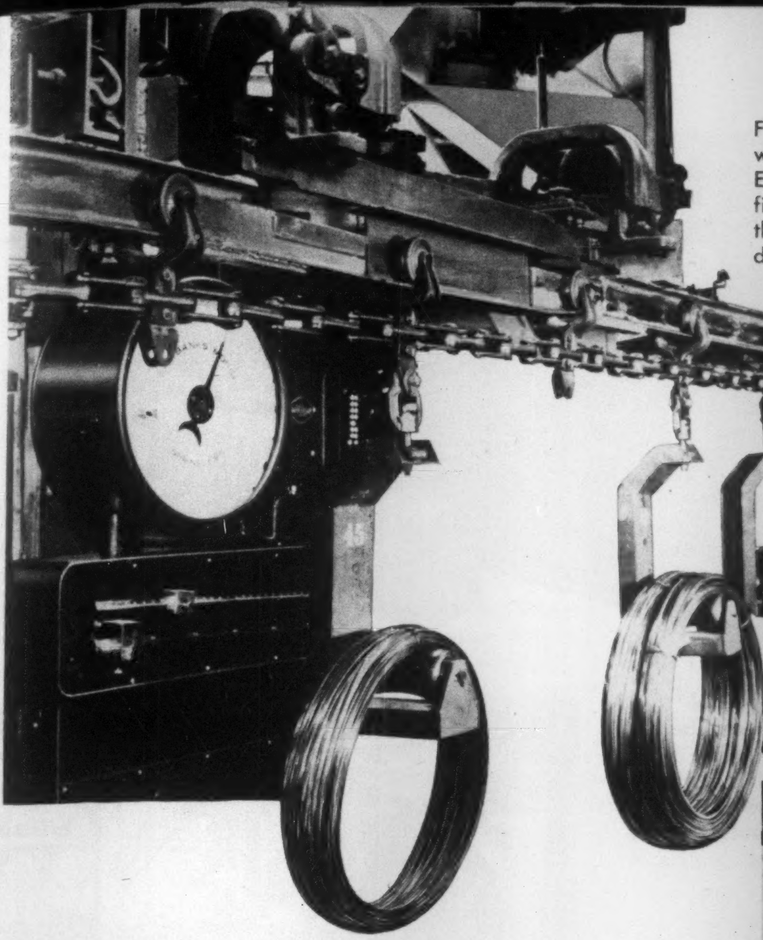


Fig. 1—Automatic weighing of steel coils while in transit on an overhead conveyor. Each trolley carrying the load is given sufficient clearance to move vertically within the chain so that the load may be read directly on the scale

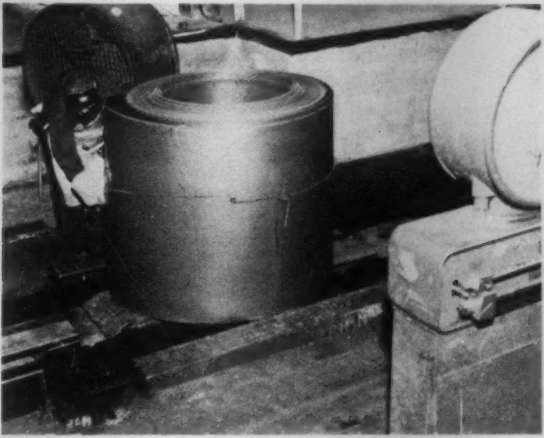


Fig. 2—Floor conveyed coils are weighed automatically as the coil is momentarily raised off the conveyor by the scale platform. After weighing the coil is returned to the conveyor

KNOW-HOW INDISPENSABLE TO AUTOMATED HANDLING

By JOHN D. RUMSEY
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Successful application of automation is manifestly a function of good design. The extent that the desired application is unique increases the importance of proper design and consideration of details however insignificant which are related to continuous trouble-free operation

ABSENCE of authoritative dictionary coverage is conducive to misunderstanding in that new words are apt to mean different things to different people — but whatever the source of definition of the new concept automation, it is understood to involve mechanized handling. Formally defined, automation is "the relating, co-ordinating, and integrating of machines, controls, and processes to the extent that partial or complete processing from the primary state to the useful end product is accomplished automatically." This can be restated for the materials handling field as simply that—"automation means the automatic handling of parts or assemblies between progressive production processes."

The most common method of transfer, used separately or in combination, to perform automatic

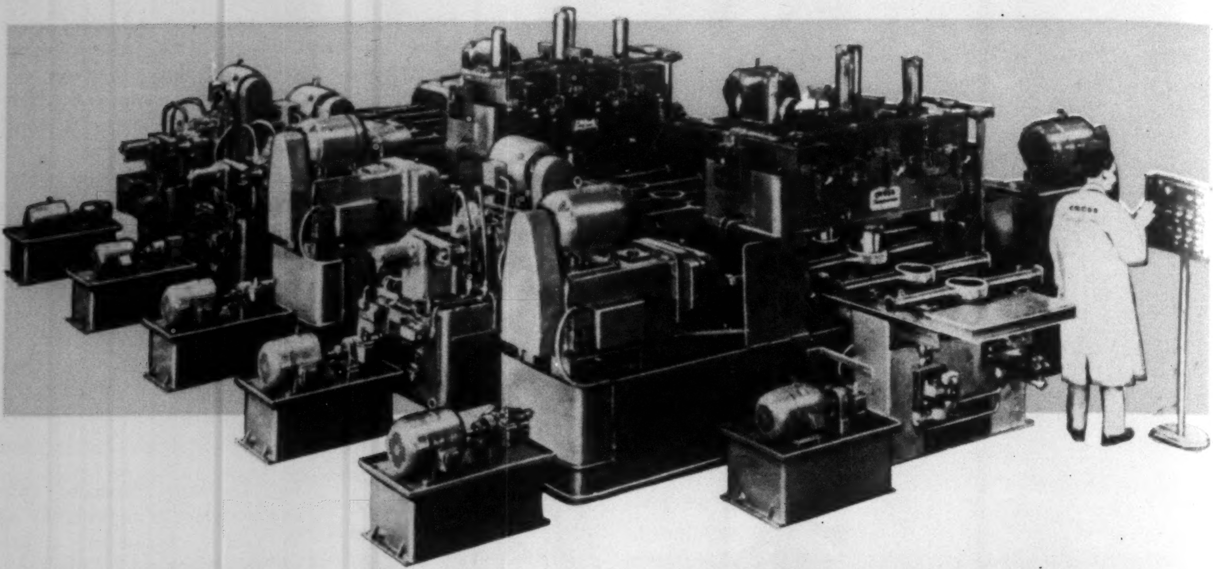

Fig. 3—Walking beam transfer method for rear axle shafts. The shafts rest on structure which is supported by V-rollers running on an inverted angle track. The whole structure is counterweighted; the lifting motion is obtained by a long shaft operating a number of pinions and racks. The horizontal motion is obtained by hydraulic cylinder

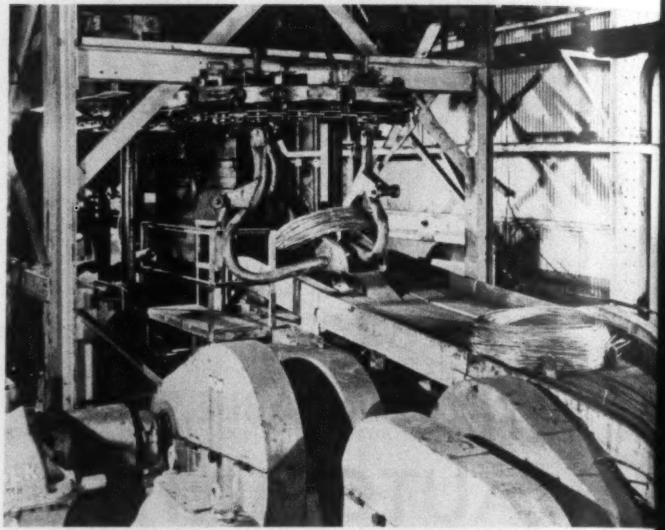

Fig. 4—Steel rod coils are automatically transferred from floor conveyor to overhead conveyor. Coil is tilted as synchronized overhead carrier hook dips into receiving position. The floor and overhead conveyor are synchronized by use of dc electrical equipment plus a mechanical tie

handling of parts between operations are:

1. Floor conveyors, such as slat and drag types.
2. Belt or wire mesh conveyors.
3. Overhead trolley conveyors.
4. Air or hydraulic cylinders.
5. The walking beam—a mechanism designed to give the motions of *Up, Forward, Down* and *Return.*
6. The shuttle bar—a mechanism with reciprocating motion which pushes parts from top, side or bottom on slider or roller bed.
7. Vibrating or oscillating conveyors.
8. Pivoting and rotating mechanisms.

Illustrations accompanying this article present some typical installations of automatic handling. It should be noted that it is always better to keep control of parts to be automatically handled; loose parts are more difficult to handle and orientation devices are costly.

▶ Design Considerations

Since most of this equipment is special in some form or another to the requirements of a particular customer, successful automation in a plant depends on good design which is based on careful attention to details and fundamental principles.

It is necessary to determine the best engineering and economic approach to the problem. The open mind and willingness to question and really think about the whole problem are required for successful automation. Can a product be simplified and possibly be redesigned to be more easily processed or manufactured and still function properly? Question the number of pieces and the number of operations that go into a product. Are they all necessary? Can any be eliminated or combined?

Investigate all the related factors in choosing a basic design for equipment. If only one unit is to be built, the design thinking and equipment selection may be different than if a large number of duplicate units are to be made. Is the equipment in a good or bad environment, such as in a laboratory or in a foundry? Will it be located where temperatures may vary widely, or be subject to the weather? It is important to get an idea from the user as to the life expectancy desired. How much abuse and misuse is the equipment likely to receive? Does the user want the equipment to have extra "eye appeal" where its operation is visible to many visitors? The relation of this equipment to other equipment in the production line must receive proper consideration. Decision as to design and selection of component equipment should be conditioned by: necessary interlocks, possible interchangeability of parts and components, and the possibility of standby equipment. These are some of many factors that will affect the basic design of the automation equipment.

The design should be simple. If possible, the use of standard equipment is often better than special equipment; for example, some customers prefer to have a standard motor coupled with a floor-mounted brake in place of a combination "brake-motor". Ease of repair and stocking of standard parts are factors in this decision. Sometimes, however, the best automation may not be obtained if based upon the use of standard equipment or standard machine tools. The object is not necessarily to apply the tools we may already have, but to develop the best equipment for the particular job in mind.

Equipment must be sturdy. It will be subject to abuse and misuse; and dependability is a prime factor in good automation equipment.

▶ Maintenance Must Be Considered

Automation equipment must be designed with maintenance in mind. Easy accessibility and easy replacement of parts are necessary. For example, solenoid valves should be wired with a short flexible cord and plugs and hose connectors should be installed between the air supply valves and the cylinders—making the changing of the solenoid valves for maintenance purposes a simple and fast matter. Solenoid valves should have a provision for manual operation by inserting a small rod through a hole in the housing for maintenance checking; this permits determining whether solenoid trouble is electrical or mechanical. It is necessary that the machine can be easily and properly lubricated and important that equipment be designed so that it can be kept clean.

Consideration of the various needs for adjustment of the equipment is most important. After equipment is first assembled, it may be necessary to adjust certain component parts; or, after equip-

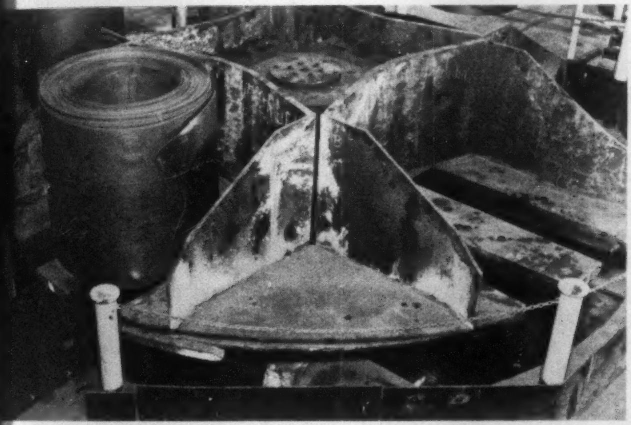

Fig. 5—Rotary transfer mechanism handles coils between two floor conveyors 90 degrees apart. The turntable lifts up, rotates, and moves down to deposit the coil on the second conveyor. Vertical lifting is accomplished by hydraulic cylinder connected to center shaft

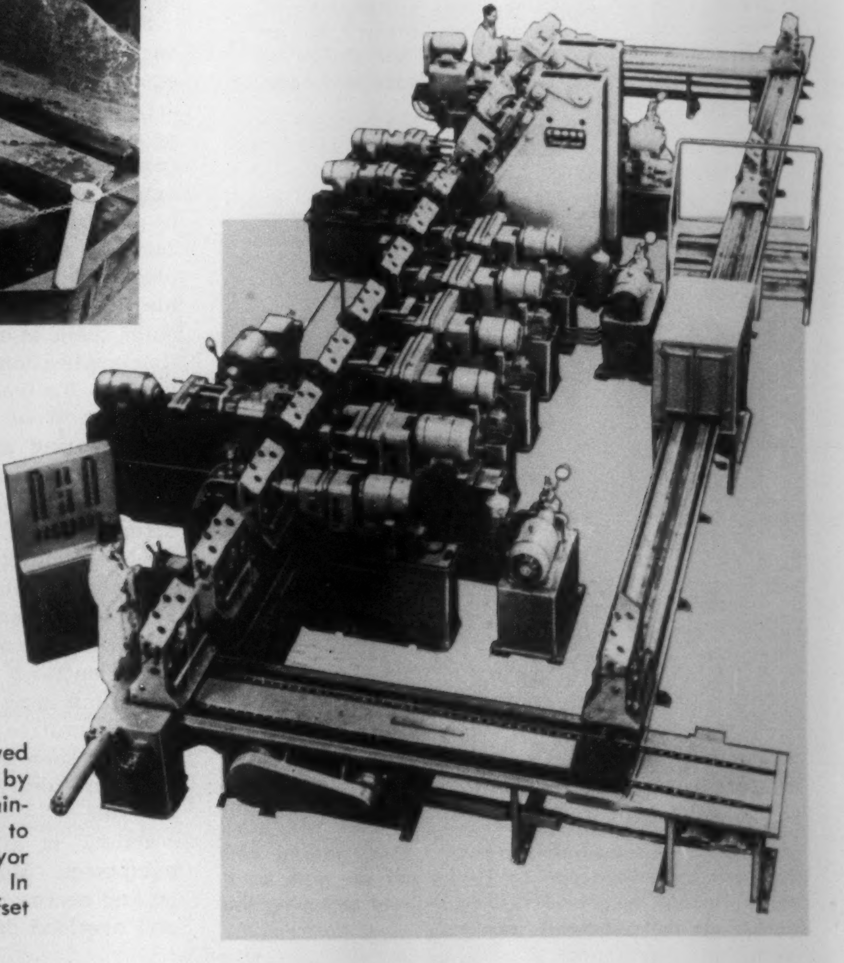

Fig. 6—Parts in special fixture are moved through various machine operations by means of a transfer bar. When machining is finished, the fixture is returned to starting point on a drag chain conveyor which pushes fixture on a slider bed. In some cases, parts are carried on offset roller chain

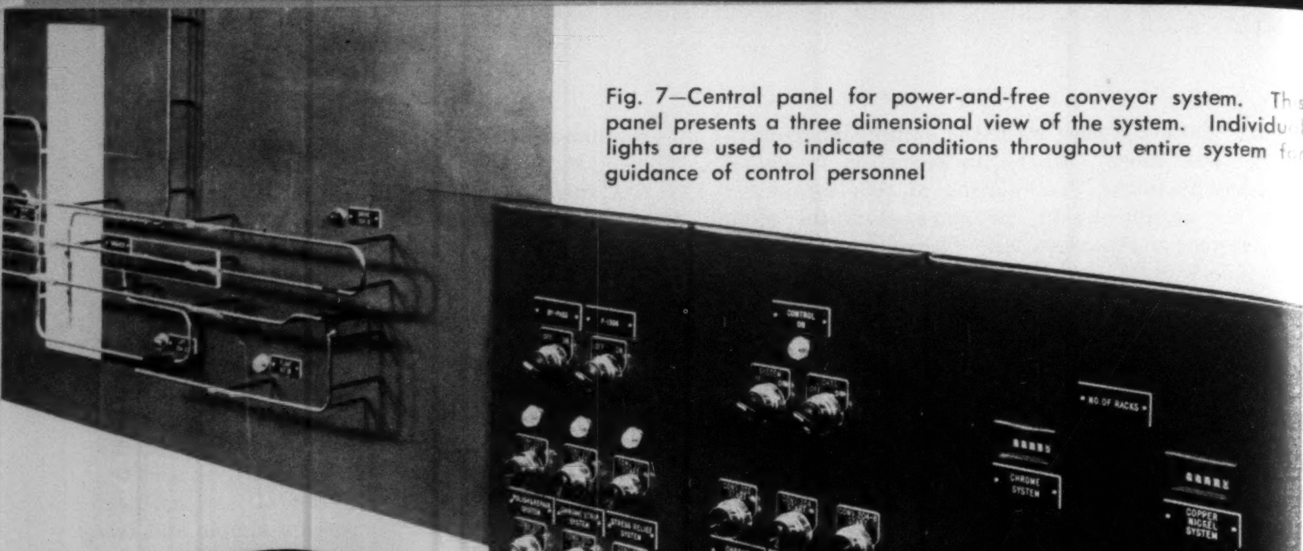

Fig. 7—Central panel for power-and-free conveyor system. This panel presents a three dimensional view of the system. Individual lights are used to indicate conditions throughout entire system for guidance of control personnel

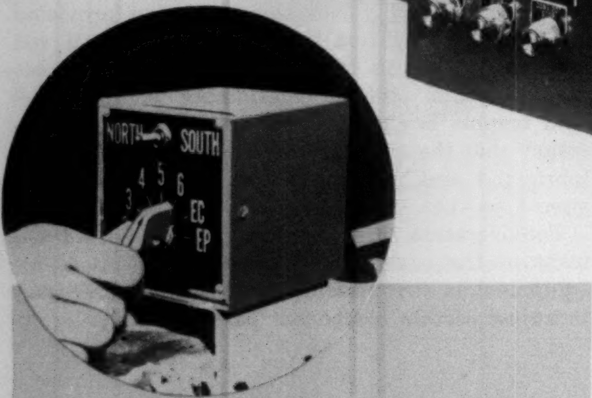

Fig. 8—Operator may predetermine destination to which carrier of power-and-free conveyor is sent. The *EC* indicates empty carrier and *EP* empty pans. The proper free conveyor will be deposited automatically at the first station or track-switch it comes to in accordance with operators request

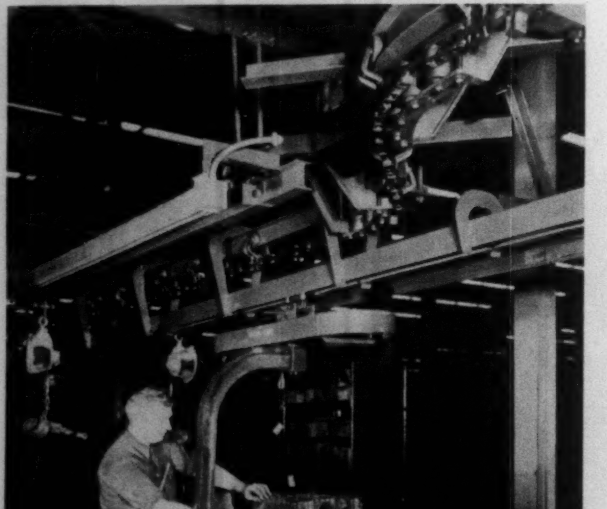

Fig. 9—Motor block is being transferred from roller conveyor to power-and-free conveyor. Many testing and assembly operations can be performed on work as it moves through successive stations without removing the block from the overhead conveyor

ment has been running a long time, it may be necessary to adjust again to take care of possible wear.

Selection and location of electrical controls are very important to the proper operation of the equipment. It often takes extra thought to properly place limit switches where they can do a dependable job and at the same time be protected from damage and be available for service. Here again, we try to use standard limit switches. It is preferred that they be consistently wired by a color or a code system and with quick-detachable plugs. The conventional precision limit switch so ideally used on industrial equipment such as machine tools, is often of little value in some automation applications in which loose tolerances are inherent. To meet these conditions, we have developed the Webb limit switch which is devised with an actuating arm of large size and liberal overtravel. This mechanism has shown very good service in converting the large movements of the actuating arm to the small travel needed to depress the plunger of a precision switch.

Design should include ample clearances, particularly where moving parts are concerned; for example, if a part is to be set upon a saddle, a wide flared entrance plate is desirable to accommodate variations in part size or location.

Conservative speeds and cycles, with consideration for inertia involved, must be used. Acceleration and deceleration forces must be carefully checked.

Safety is an important factor in automation equipment. Moving parts must be properly guarded and necessary additional guards, limit switches, and overload devices must be added to protect the men, the machine, and the parts. It is very helpful in the original assembly of automatic equipment, as well as for subsequent maintenance, to have all component parts properly tagged or identified. All electrical limit switches, valve solenoids, etc., should have wires terminate in readily accessible panels for easy trouble-shooting. Wiring diagrams and additional information necessary to properly maintain automation equipment should be posted nearby, such as in the back of the cover of the control panel, for easy availability for the maintenance men who have to do the trouble-shooting.

▶ Disadvantages Can Be Minimized

From this discussion of design principles it is obvious that there are some disadvantages to automation. Three major disadvantages are:

1. Down-time for any reason becomes increasingly costly.
2. Larger money investment required.
3. Automation increases the need for more highly skilled maintenance men.

Downtime is becoming of increasing importance because a larger number of operations are being combined in automation programs. Hence, downtime can be very costly because it is cumulative; for example, every delay occurring in one section of an automated sequence will shut down all other parts. We thus have a very high premium on dependability. Some plants are using what is called "segmented automation" to minimize cost of downtime on large automation jobs.

Downtime can be divided into two basic classifications—predictable down-time, such as changing tools, cleaning a machine, preventive maintenance, etc., and nonpredictable down-time, such as lost time resulting from breakdowns. Great strides are being made in eliminating unnecessary down-time from predictable causes. A scheduled program of changing tools before they are worn out or broken, cleaning machines, proper lubrication, etc., can be carried out during lunch hours, or on shifts when the production department is down. Nonpredictable down-time is usually due to poor design. This may be eliminated by engineers making the equipment more simple, more rugged, and with safety mechanisms to prevent abuses and misuse of the equipment. Preventive maintenance will help minimize breakdowns.

The second disadvantage, that of increased investment, is most often nullified by increased savings. Automation equipment should be designed with an eye to possible future changes in the product so that its life may be stretched over an increased time. The third disadvantage, that of more highly skilled maintenance men being required, may be brought to a minimum by proper design of simple and sturdy equipment with the thought in mind of easy maintenance and repair.

However, considered from a positive point of view, it is also obvious that properly designed automation will produce these advantages:

1. Increased production per unit of time.
2. Less processing space required per unit produced.
3. "In Process" inventory reduced to a new low.
4. "In Process" inventory will be "first in, first out."
5. Labor costs will show a considerable drop per unit produced.
6. Less chance for scrap or waste.
7. More uniform results because of minimum dependence on the human element.

These advantages can be an impressive reward for the time and effort spent in considering the details so necessary in the planning and designing stage of a successful, automated handling system.

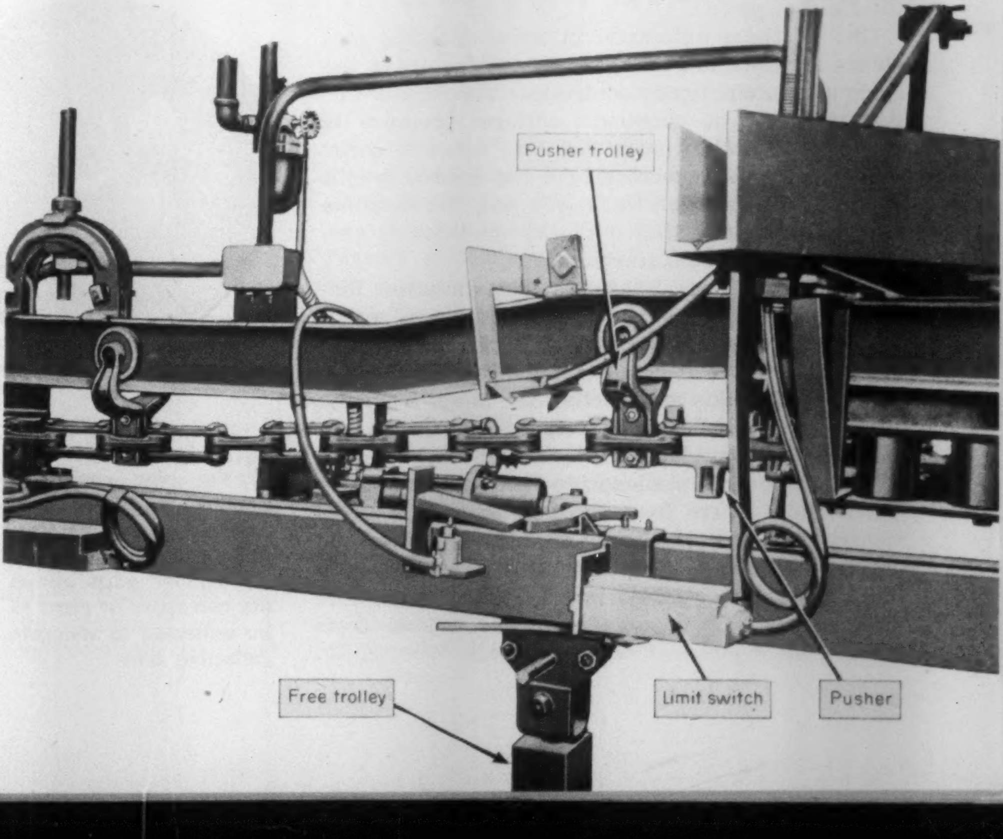

Fig. 10—Details of power-and-free conveyor system at pickup point. Top power chain travels continuously like regular conveyor. Free trolley, which supports the material being transported, moves along lower track when engaged with pusher of power chain. Other components prevent more than one trolley from being moved by pusher. Free conveyors are introduced into the system at various desired stations and subsequently are dispatched to different stations on branch tracks without affecting continuous circulation of the power chain

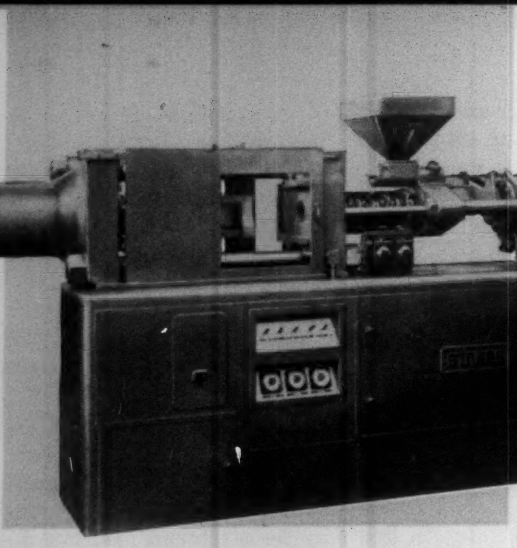

Fig. 1—Automatic injection molding machine. Hopper fed, automatically cycled, and ejecting mechanically, the only requirement on the operator is to supply material and dispose of parts produced

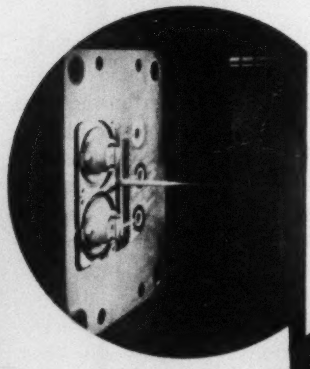

Fig. 2—This view shows 5-cavity mold for two di- ferent fishing reel pa just after the press h opened

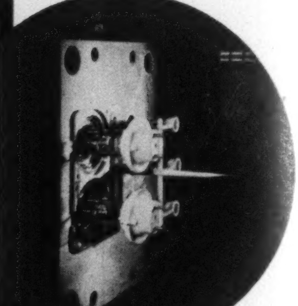

Fig. 3 — De-gating of parts is accomplished during ejection of the parts and runner system by hydraulically operated, embedded knockout pins

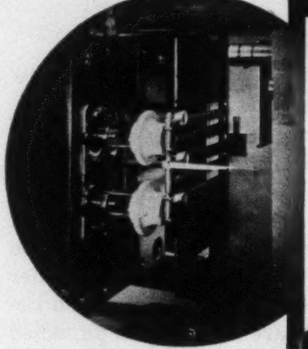

Fig. 4—When the parts are in the fully ejected position the stripping comb starts across the mold face

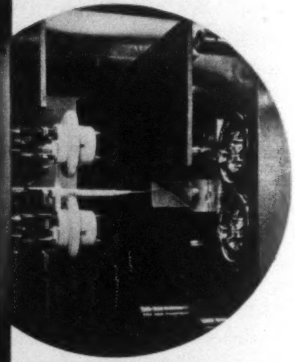

Fig. 5—As the comb advances, a knife blade shears the sprue thread at the stationary mold face

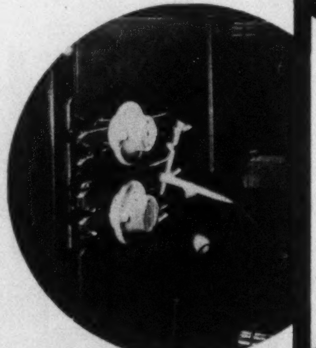

Fig. 6—With the comb in its extended position, the knockout pins are retracted. The sprue and runners and the three smaller parts are shown falling to the discharge chute

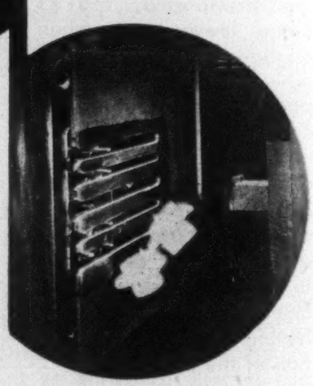

Fig. 7—Further retraction of the pins completes ejection and the two larger parts can be seen falling. Prior ejection of the smaller parts allows the two types of parts to be deflected to separate collecting bins

AUTOMATED INJECTION MOLDING

AUTOMATIC production of injection molded parts from plastic materials is possible with a machine featuring mechanical detachment of sprues and runners and positive ejection of parts in conjunction with hopper feeding of material and automatic cycling. F. J. Stokes Machine Co. feels that one operator can handle as many as ten of their machines since he has only to keep the feed hoppers filled with material and dispose of the finished pieces.

One of these automatic injection molding machines is shown in *Fig.* 1. Steps and factors in the cycle are automatically controlled: Temperature of material is kept constant; uniform pressure is maintained; and all operations are timed to occur in the proper sequence and for the desired length of time. If the cycle is interrupted, the machine will automatically stop until the condition is corrected and the press started again.

As shown in *Figs.* 2 through 7, this machine features positive automatic ejection of pieces which have been separated from the runners. This separation of pieces and runners is accomplished while the knockout pins are ejecting the stock from the mold cavities. All stock is stripped from the knockout pins by a mechanically actuated comb. Design of comb knockout pin length or actuation can strip parts and runners from the pins in a desired sequence. Automatic delivery of different parts and runners to segregated bins is possible by deflecting falling parts to selected bins in timed relation to the stepped stripping of the various sections from the knockout pins.

The greatest challenge to the control engineer's breadth of knowledge in all physical systems comes when analyzing the process itself. Armed with mathematical tools and with a firm grasp on engineering physics he can apply the system approach to a wide variety of problems in many fields and determine the optimum control system for each

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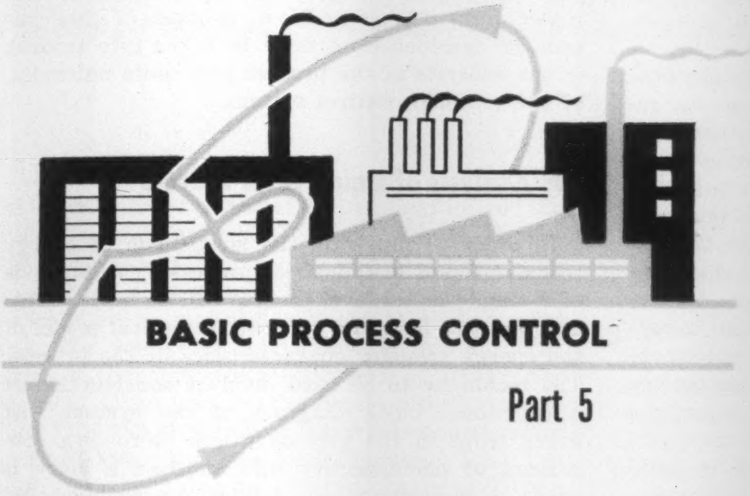

BASIC PROCESS CONTROL

Part 5

ANALYSIS OF PROCESS CHARACTERISTICS

THE PURPOSE of applying automatic control to a process is to produce products meeting definite specifications. Complexity of modern processes imposes exacting demands upon the performance of automatic control systems used for process control. Because of these exacting requirements, the process control system selected should be based upon a system design which considers the characteristics of all components in the system including the process itself.

A system analysis requires that the characteristics of all components in the system be reduced to common mathematical expressions. The transfer function and frequency response concepts previously discussed in this series allow all component characteristics to be reduced to this common denominator. Accordingly, Part 4 of this series was concerned with the frequency response and transfer functions of commercially available industrial controllers. Since the performance of any process control system is dependent on the characteristics of the process being controlled, it now becomes necessary to examine some of the various methods available for determining process dynamic characteristics.

There are several considerations which must be taken into account before the mathematical analysis of a process is made. Problems of physical systems call for the use of various mathematical methods and tools; most important of these is the differential equation. It is important because it may be directly useful in obtaining many desired solutions. In addition, it has great value as a basis for classifying physical systems and for organizing the subject of the response of physical systems.

To simplify this discussion, only a certain class of physical systems called simple systems will be discussed. A physical system is simple if its differential equation is a first or second-order linear ordinary differential equation with constant coefficients. This statement gives four qualifications to the differential equation—its linearity, the fact that it is ordinary as opposed to partial, its order, and the fact that its coefficients are constant. Each of these mathematical restrictions have important physical meanings, as will be pointed out later. Systems failing in any way to meet all of these restrictions are called complex systems.

One of the conditions to be met by any physical system, to be a simple system, is that its response should be given by ordinary, rather than partial, differential equations. The condition is actually never met exactly, and therefore it is important to understand the approximation involved. Physical systems exist in time and space. Mathematical treatment of such systems would therefore be expected in general to lead to equations involving at least two independent variables—one to represent time, and one or more to represent space conditions. Mathematical physics might be expected to deal directly with partial differential equations only, whereas ordinary differential equations would enter only in a purely mathematical role in problems dealing with the partial equations. However, it is true that many physical systems are treated directly in terms of ordinary differential equations, but such treatment is always more or less an approximation in the physics, no matter how rigorous the mathematics.

When an extended property, which in reality is distributed over a sizeable portion of space, is treated as existing only at one point, it is referred to as being "lumped" at a single point. This lumping of properties of physical systems is used in other fields, particularly in electrical engineering where the concept of lumped circuit parameters is commonly used. In analysis of large physical systems, assumption of lumped parameters depends upon individual circumstances of a particular problem. In general, practical problems in system engineering assume lumped parameters.

Another distinguishing factor of physical systems is the fact that the forcing of any physical system involves the flow of some form of energy throughout the system. Although the forcing and the response are usually expressed in quantities other than energy or power, the fact remains that any physical process may be thought of as a power transmission problem. Because of this, impedance considerations must be taken into account in the analysis of the process and, quite naturally, of the complete control system.

Analysis of Liquid Level Process

In order to illustrate the mechanism of energy transfer found in industrial processes, an analysis of a simple liquid level process will be made. This analysis will be based on a mathematical model of the energy transfer characteristics of the process. The technique to be used involves construction of a functional block diagram of the system. At every point in the process where there is a conversion of one quantity into another, a block is used. A quantity which defines the mathematical operation performed within its boundaries is placed in the block. When the blocks are connected according to the signal flow, the result is a diagram which mathematically defines the process.

A schematic diagram of the liquid level process to be analyzed is shown in *Fig.* 1. The process variable of interest is the level *H* of the liquid in

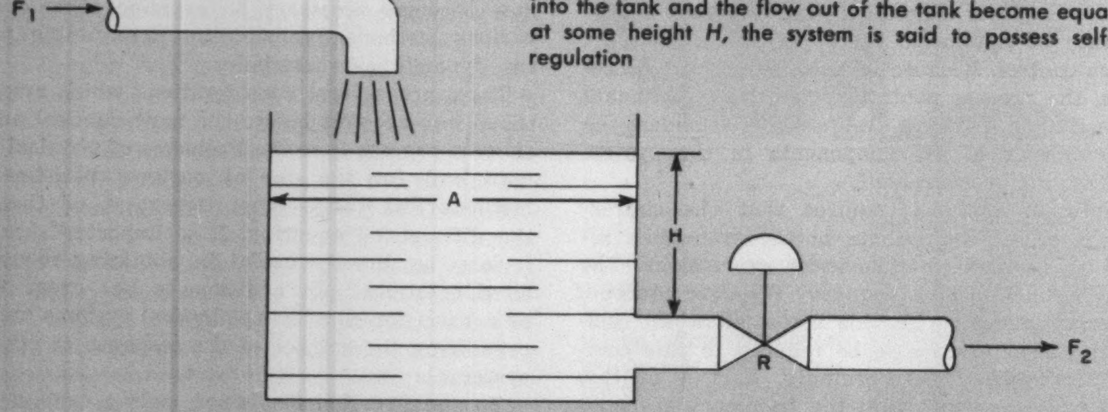

Fig. 1—Single capacity liquid level process. If the flow into the tank and the flow out of the tank become equal at some height *H*, the system is said to possess self-regulation

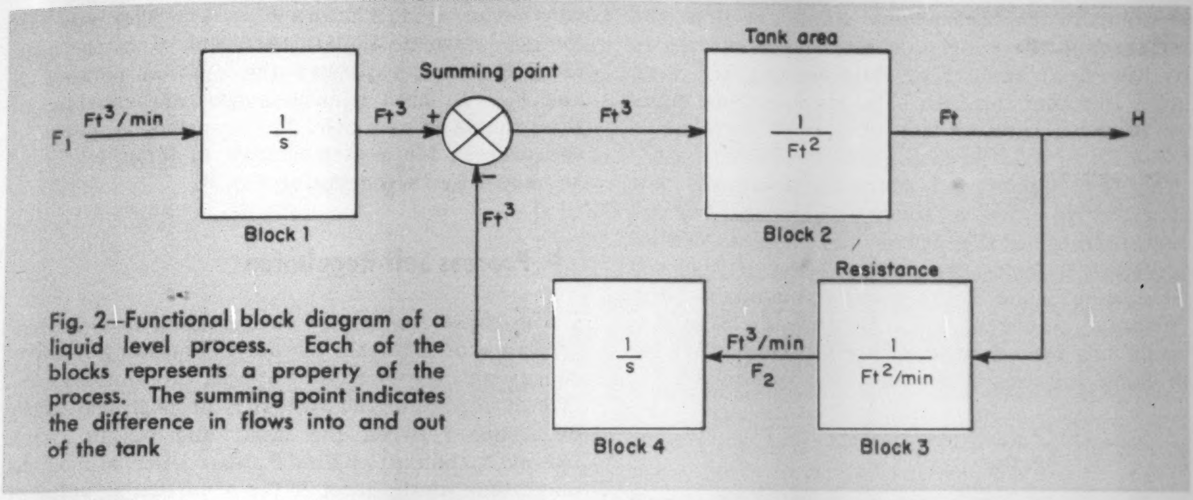

Fig. 2--Functional block diagram of a liquid level process. Each of the blocks represents a property of the process. The summing point indicates the difference in flows into and out of the tank

the tank. The functional block diagram of this process may be arrived at by applying the principles discussed in Part 3. During any finite time interval the flow rate F_1 in cubic feet per minute causes a given quantity of liquid to spill into the tank. The volume of liquid flowing into the tank during a time interval is obtained by integrating this flow. Consequently, the function performed in block 1 of *Fig.* 2 is one of integration as signified by the LaPlace notation for integration, 1/s.

At any given instant of time, there will be a net quantity of fluid in the tank. This quantity will be the difference between the volume that has spilled into the tank and the volume that has left the tank, and will naturally depend upon the flow rates F_1 and F_2. This function is represented by the summing point of *Fig.* 2. The amount of fluid remaining in the tank is the sum of the two signals feeding into the summing point. This quantity of fluid, expressed in terms of a volume, is then divided by the area of the tank to give the height of the fluid in the tank at any instant of time. This function is shown in block 2 of *Fig.* 2. This height or level H is the output of the block diagram, since it is the variable selected to indicate the state of the process.

The portion of the block diagram formulated to this point in the analysis can be used to illustrate an important dynamic characteristic of all physical systems. Assuming that there is no flow out of the tank (resistance R is infinite) the output of the summing point is equal to its input, and blocks 1 and 2 are in series. Their combined characteristics can be expressed in transfer function form as

$$\frac{H}{F_1}(s) = \frac{1}{As} \qquad (1)$$

where

H = height of fluid in feet
F_1 = input flow in cubic feet per minute
A = area of tank in square feet
s = LaPlacian operator d/dt

Equation 1 shows that the tank acts mathematically as an integrator and illustrates the physical fact that it collects the flow coming into the tank. The level H serves to indicate the results of the integration and is inversely proportional to the area of the tank. Thus the area of the tank represents the capacity of the tank and indicates the amount of liquid required to raise the level of the tank one foot. The capacity then is a measure of the ability of the tank to store fluid. The mathematical definition of the energy storage characteristics of a volume expressed by Equation 1 is evident, yet it is often overlooked in visualizing the performance of control systems. The importance of this to a dynamics consideration cannot be overemphasized.

Should the flow into the tank be expressed in weight per unit of time instead of volume per unit of time, the effective capacity would be proportional to the density of the fluid. The amount of fluid in the tank is now expressed in weight, which, when divided by the density, yields the volume of the fluid. The volume divided by the area again gives the height. Consequently, the effective capacity is now equal to ρA. This is the more commonly used expression for the capacity of a volume.

The original analysis, however, was concerned with a process having a net flow from the tank. The amount of flow out of the tank will depend upon the size of the restriction and the potential energy force causing the flow. Therefore, by definition, the energy loss in overcoming the resistance of the restriction is equal to the flow rate multiplied by the effective resistance of the restriction. Since the flow rate through the restriction is desired, the function appearing in block 3 is the reciprocal of the resistance or the admittance of the restriction.

In order to obtain the total quantity of fluid remaining in the tank at any instant of time, the flow through the restriction must be integrated to give the total amount of fluid leaving the tank during this time interval. The mathematical function of integration is then performed by block 4 of *Fig.* 2.

The four blocks and summing point are now connected to give a functional block diagram which mathematically defines the process. Notice that block 2 forms the forward loop of a closed loop system, while blocks 3 and 4 combine to form a negative feedback path. Because a closed-loop system has been formed, the general equation for the characteristics of a closed-loop system,

$$\frac{C}{R} = \frac{g_1 g_2}{1 + h g_1 g_2} \qquad (2)$$

can be used to obtain the response of the liquid level process. From the block diagram it is evident that

$$g_1 g_2 = \frac{1}{A} \qquad (3)$$

and

$$h = \frac{1}{Rs} \qquad (4)$$

Therefore, the characteristics of the liquid level process are

$$\frac{H}{F_1}(s) = \frac{R}{1 + ARs} \qquad (5)$$

Had the output flow F_2 been chosen as the variable indicating the state of the process, the transfer function would have been

$$\frac{F_2}{F_1}(s) = \frac{1}{1 + ARs} \qquad (6)$$

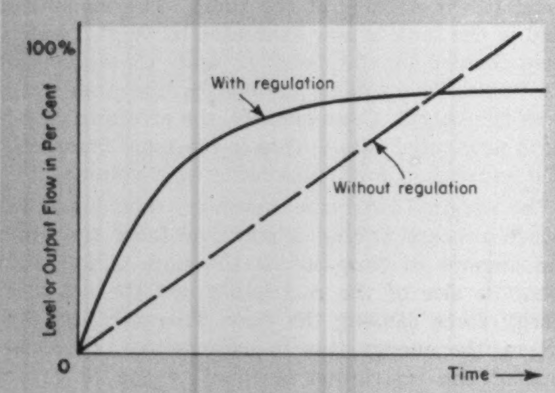

Fig. 3—Transient response of a liquid level process with and without self-regulation. If the output flow from the tank is not a function of the height of fluid in the tank, the process is not self-regulated

where $g_1 g_2 = 1/AR$ and $h = 1/s$. The only difference between Equations 5 and 6 is the gain term R which expresses the relation between H and F_2. In both equations the time constant of the process is $\tau = AR$. The transient response of the process for a step change in input would be as shown by the curves of *Fig.* 3.

Process Self-Regulation

The block diagram of *Fig.* 2 illustrates the performance of a physical system containing a single energy storage element. It can be seen that the rate of change of the level H is proportional to the difference between the input and output flows. However, the output flow F_2 also depends upon the magnitude of the level H for a particular value of R. Therefore, providing the tank does not overflow or empty, it is possible for H to adjust to a height so that the output flow is equal to the input flow, causing H to become constant at a new level as illustrated by the curve in *Fig.* 3 whose slope is approaching zero. Thus the transient response of a first-order process to a disturbance dies out at a rate proportional to the remaining change yet to be made to restore the system to its initial condition. Physical systems with these characteristics eventually regulate themselves to a new steady-state level and are said to possess self-regulation.

Negative feedback pictured in *Fig.* 2 is responsible for this self-regulation. If a constant-speed pump were placed in the output instead of the restriction, the feedback path would be broken and the output flow would become independent of the level in the tank—the process would no longer possess self-regulation. If the input flow rate were larger than the constant output flow, the transient response of the process level for a step input would be as shown by the straight-line curve of *Fig.* 3.

Process self-regulation may be an important factor influencing the design of the control system. Its absence complicates the control problem in that it contributes to the instability of the system. Its regulatory effort is usually not sufficient to make the process completely self-controlling, since a considerable amount of control effort is usually required for satisfactory control. Generally, enough self-regulation is present to insure some contribution to control system stability.

Dead Time

In certain processes, particularly continuous ones where it is necessary to transfer energy by means of a fluid flowing through some distance at a finite velocity, a type of delay called dead time is encountered. Dead time can be created by the physical arrangement of the system components such as the location of the measuring element at a distance from the process, or it may occur as an integral part of the process reaction. This occurs most often in chemical processes and is difficult to eliminate. The measurement and control

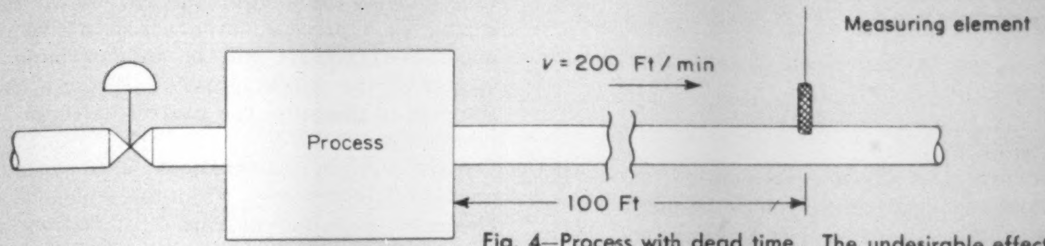

Fig. 4—Process with dead time. The undesirable effects of dead time are the resulting absence of control during the dead time period, and the large phase shift caused

of pH is an example.

Dead time has a serious effect upon automatic control in that a delay exists during which automatic control has no effect. Its theoretical representation is based upon transmission line theory[1] which states that long lengths of pipe or tubing may be represented by an infinite series of first-order lags. Dead time may be expressed in transfer function form as

$$\lim_{n \to \infty} \frac{1}{\left(1 + \dfrac{T_D s}{n}\right)^n} = \varepsilon^{-T_D s} \qquad (7)$$

Effect of dead time on process control may be illustrated by expressing it in frequency response form. A process with the measuring element located 100 feet from the process is shown in *Fig.* 4. The velocity of the flow from the process is assumed to be 200 feet per minute. It can be seen that if a slug of material in the desired state leaves a process, it will be ½ minute before this slug is transported to the measuring element where its state is measured. Assuming small energy losses, as is usually the case, there will be no attenuation and the signal amplitude remains constant. The gain then is unity and does not change with frequency. The phase shift, however, does change with frequency; the amount may be calculated by using the expression

$$\phi = 360\, T_D f \qquad (8)$$

where ϕ = phase lag in degrees, T_D = dead time in minutes, and f = frequency in cycles per minute.

The Bode diagram of the frequency response for dead time is shown in *Fig.* 5. Because of the presence of phase shift without a corresponding reduction in signal size, dead time has a serious effect on control system response. The large amounts of phase shift add to the total open-loop phase shift and usually force a reduction in the amount of controller gain and reset that can be used. This results in a slower system response for stable control, since the total allowable open-loop phase lag in the system occurs at a much lower frequency. It follows then that the presence of dead time causes unstable control even for relatively low frequency disturbances, and that it should be kept to a minimum whenever possible.

Dead time causes no change in the shape of the response curve but merely delays or shifts the response to a later time, as illustrated by the transient response curve of a first-order process with dead time shown in *Fig.* 6. With dead time in the process, a change is not indicated until a time interval equal to the dead time has passed. This is a most serious lag since whatever happens during this period of time is inevitable.

▶ Analysis of a Pressure Process

The example of a liquid level process has served to illustrate the basic approach to process analysis. In addition, two characteristics which have an important bearing on the controllability of in-

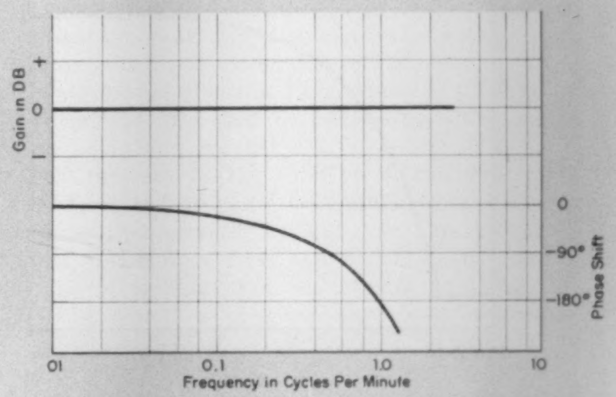

Fig. 5—Bode diagram for dead time. This plot emphasizes the phase shift problem caused by dead time

dustrial processes have been pointed out—self-regulation and dead time. It now becomes necessary to examine the subject of process analysis in further detail and to outline a practical approach to the problem.

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[1] References are tabulated at end of article.

Any general approach to the subject is naturally complicated by the diversity of industrial processes, but similarities can be found which apply to a large number of apparently different physical systems. This similarity is due to the mathematical similarity expressed by the laws governing energy transfer in physical systems. We have shown in Part 2 of this series that this mathematical similarity allows analogies to be developed which aid in calculating the characteristics of physical systems. These analogies merely denote that the state of dynamic equilibrium can be represented by the same equation—the basis is mathematical instead of physical.

Choice of the analogy depends upon the background of the particular engineer making the analysis and to a certain extent upon the character of the problem. Some control engineers prefer to construct hydraulic analogies while others prefer to use electrical analogies. Because of the highly developed electric circuit theory and the utility of the electronic analog computer[2], the electrical analogy has received much use in system analysis[3]. Because of this, the following analysis of a pressure process will be based upon an electrical analogy.

The pressure process to be analyzed is shown schematically in *Fig.* 7. It consists of a surge tank and air heater of known volume supplied by a pressure P_i through a control valve. For purposes of this analysis the load on the process can be represented as a pressure drop across a linear resistance. The problem will be to determine the response of the output pressure P_o for a change in the supply pressure, the control valve, or the load resistance.

First step in the analysis is to formulate an analog of the process. From the table of analogous elements presented in Part 2, it follows that the pressure process can be represented by the electrical circuit shown in *Fig.* 8. Action of the control valve has been represented by a variable nonlinear restriction, and the load by an adjustable linear resistance. Resistance to the air flowing through the pipe between the control valve and the air heater has been neglected, as has its capacity. This may not always be a valid assumption, as it will depend upon the relative physical size of the various components in the process. If this assumption cannot be made, the equivalent capacity of the pipe should be treated as a lumped parameter and calculated in the same manner as the tank capacity. Its capacitance should be added to that of the tank, since the volume of the pipe acts as a side capacity in parallel with the surge tank capacity.

Effective resistance to air flow can be calculated using the relation

$$R_F = \frac{\Delta P}{W} \qquad (9)$$

where R_F = equivalent electrical resistance, ΔP = pressure drop across pipe, and W = weight flow rate.

A number of analogies between mass flow systems and electrical circuits are possible but this analogy is the usual one used by acoustical engineers in dealing with similar problems. This resistance acts in series with the effective valve resistance and can be added to resistance R. With proper sizing of the circuit parameters of the electrical network shown in *Fig.* 8, the output voltage signified by P_o will be exactly analogous to the output pressure of the process.

Equivalent electrical capacity of the surge tank can be derived from the general gas law $PV = mrT$. For the assumption of a constant volume V and temperature T the change in pressure with respect to time becomes

$$\frac{dP}{dt} V = rT \frac{dm}{dt} \qquad (10)$$

Rearranging

$$\frac{dm}{dt} = \frac{V}{rT} \frac{dP}{dt} \qquad (11)$$

If this equation is compared with the expression for current flowing in an electrical condenser,

$$i = \frac{dq}{dt} = C \frac{dE}{dt} \qquad (12)$$

then

$$C_e = \frac{V}{rT} \qquad (13)$$

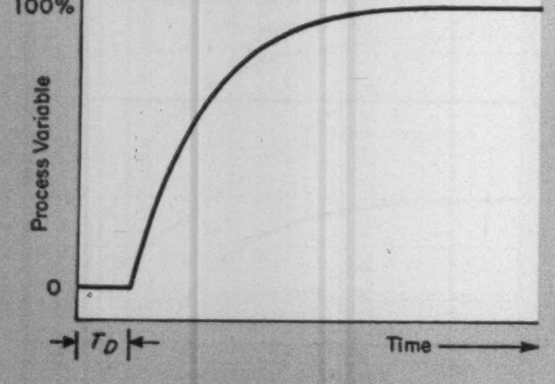


Fig. 6—Transient response of a first-order process with dead time. During the period T_D, no control action is possible

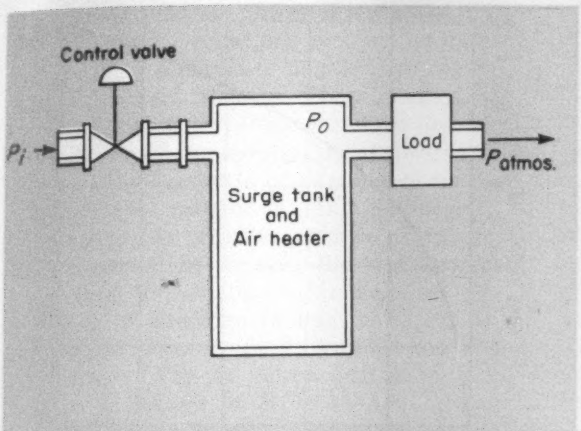


Fig. 7—Schematic diagram of a pressure process. The load is represented by a pressure drop across a linear resistance

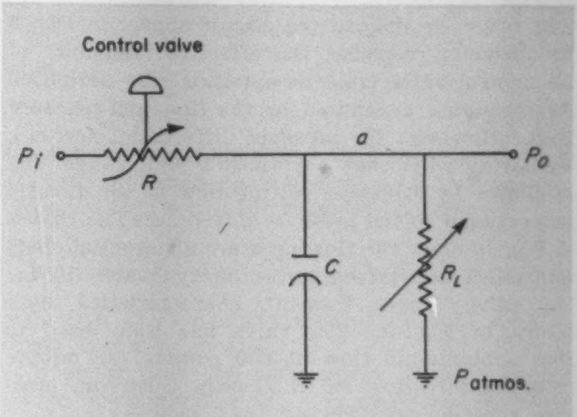


Fig. 8—Electrical equivalent circuit of the process in *Fig. 7*. The control valve is represented by a nonlinear resistance, the load by a linear resistance

where the voltage E is analogous to the pressure P, and the mass of air m in the volume is analogous to the electrical charge q. The equivalent electrical capacitance can be obtained from the physical parameters of the process by using Equation 13.

Effective resistance of the control valve is not so easily obtained due to the physical nature of the service. The spindle travel of a diaphragm-operated control valve is substantially proportional to the control signal from the controller. This relationship can be made precise if a positioning device is employed. Proportionality between the area of the valve opening and the spindle travel will depend upon the design of the valve plug. For the ordinary rectangular port or bevel plug valve, the area is substantially directly proportional to the spindle travel, while the parabolic plug, the V-port, and the developed V-port plug all have a nonlinear relation between area and spindle travel. It follows that if the valve area is proportional to spindle travel and if there is a constant pressure difference across the valve, the flow is proportional to the spindle travel, and hence, to control action.

Since a control valve generally controls the flow of fluids or gases, it acts as a variable orifice or restriction. The laws of fluid mechanics are applicable, particularly the formula for streamlined flow through an orifice:

$$Q = KA\sqrt{2gh} \qquad (14)$$

where

Q = flow in cubic feet per second
K = orifice constant
A = area in square feet
g = acceleration due to gravity
h = pressure head in feet

This equation shows that flow is directly proportional to the area and proportional to the square root of the pressure head. However, the control valve is actually a submerged orifice over which a pressure differential exists, and

$$Q = KA\sqrt{2g(h_1 - h_2)} \qquad (15)$$

where h_1 = pressure head in feet upstream and h_2 = pressure head in feet downstream.

In the flow of gases, an adiabatic change from the high pressure region to the low pressure region is ordinarily encountered. A gas is compressible, and in flowing from an orifice it changes in volume and therefore in internal energy; a practical equation must take these effects into account. The accepted equation is

$$Q = KA\sqrt{\frac{(h_1 - h_2)\,h_2}{g}} \qquad (16)$$

Units are the same as in Equation 15. The value of K determines the amount of flow that can be handled by the control valve, and depends upon its design. The area A depends upon the position of the valve stem and the design of the valve plug. The flow-lift characteristics of a valve widely used in process control are shown in *Fig.* 9.

Relationships given in Equations 14, 15, and 16 or variations are used in estimating valve sizes. These equations are subject, however, to an important limitation. For the flow of gases through an orifice, the velocity is limited to a velocity equal to the acoustic velocity. At this point no further increase in flow can be obtained because the gas is moving at a velocity as great as the speed at which a pressure wave can be transmitted through the restriction under the existing conditions. This velocity is known as the velocity of critical flow and is usually assumed to occur at a throat pressure of 53 per cent of the upstream absolute pressure. It is important that the velocity does not approach this value for any control application because, if it did, the valve would not be able to effectively control the flow.

In order to analyze the circuit shown in *Fig.* 8 for pressure response, the effective resistance of the control valve must be obtained. By definition the resistance depends upon the flow and pressure drop. However, the pressure differential across a regulating valve may vary over a wide range, and as shown by Equation 16, the flow is not directly proportional to the pressure difference. The curves of *Fig.* 10 show the flow-pressure differential characteristics for various percentages of valve lift for the valve whose flow-lift characteristics were shown in *Fig.* 9. The valve has been sized to give a maximum flow of 600 pounds per minute at a pressure drop of 57.35 psia. Upstream pressure remains constant at 114.7 psia.

Curves of *Fig.* 10 show that the effective resistance of the control valve is nonlinear. For instance, with a valve opening of 80 per cent, the effective resistance for a flow of 300 pounds per minute will be 39/300 = 0.13 psi per pound per minute. For a flow of 200 pounds per minute and for the same valve opening the resistance will be 12.5/200 = 0.0625 psi per pound per minute. This nonlinearity will result in a differential equation with variable coefficients and will not satisfy the requirements for a simple system. If the assumption is made that only small disturbances are introduced to the system, the nonlinearity can be neglected. This technique for linearizing equations is used widely in dynamic analysis and yields results with acceptable errors. To illustrate the errors involved in such an approximation, note the linear flow-differential pressure curve for a mean flow of 300 pounds per minute at 80% valve opening shown in *Fig.* 10.

Assumed characteristics of the process load are shown by the curves of *Fig.* 11. The resistance at any load setting remains constant for all flows. This is contrasted with the nonlinear resistance curves of *Fig.* 10 and illustrates the basic difference between the problems involved in the analysis of pneumatic and electric systems.

Based on this knowledge of system operation we can now proceed to determine the dynamic relations which exist in the pressure process. By writing a current flow equation about node *a* of the electrical network shown in *Fig.* 8, the following differential equation can be obtained:

$$\frac{P_i - P_o}{R} = C\,\frac{dP_o}{dt} + \frac{P_o}{R_L} \qquad (17)$$

Ground reference pressure is assumed to be atmospheric. Re-arranging Equation 17 gives

$$R_L P_i = R R_L C s P_o + R P_o + R_L P_o \qquad (18)$$

where $s = d/dt$.

Output pressure response for a change in supply pressure can be found immediately from Equation 18, since the equation consists of one independent variable P_i and one dependent variable P_o. It can be seen that a change in the supply pressure mathematically involves the forcing of the independent variable which, in differential equations, is known as direct forcing. This means that for the assumption of linear resistance the pressure process can be represented by a differential equation with constant coefficients. Its transfer function can be determined directly.

There are, however, cases where the system is forced in a different way—by the changing of one or more of the system properties. Response of systems forced in this way is said to be due to parametric forcing. Changes made to the control valve resistance or the load resistance of the pressure process are examples of this type of forcing.

From a mathematical standpoint, parametric forcing may be identified with variable coefficients since one or more of the coefficients of the differential equation are time dependent. This also violates one of the conditions put on simple systems, so that the differential equations obtained

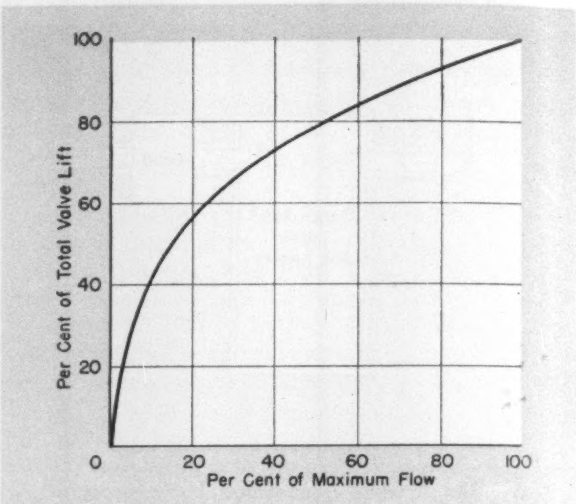
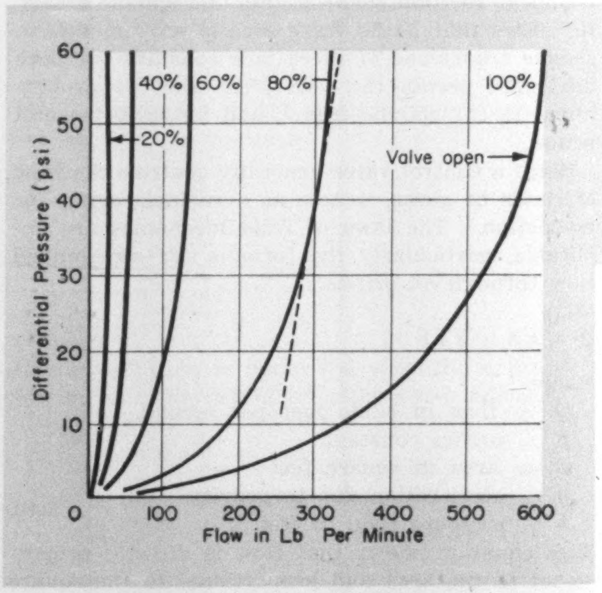


Fig. 9—Flow-lift characteristics of a V-ported, equal percentage, double-ported valve



for changes in control valve position or load resistance are not ordinary equations. Therefore, the differential equations met in parametric forcing are more difficult to handle than corresponding ones for direct forcing. Consequently, the technique of small perturbations must once again be used to obtain the process dynamic response. Because of the condition of parametric forcing, there are now two restrictions on the linearity of the response of the pressure process. Happily, both of these restrictions concern the nonlinearity of the same type of variable, the resistance.

Effect of small variations in R, R_L, anr P_i on the output pressure is determined mathematically as follows. For an increase in R of $+\Delta R$ there will be a change in P_o of $-\Delta P_{o1}$ giving a new value of output pressure $P_{os} - \Delta P_{o1}$, where P_{os} is the steady state value of the output pressure. An increase in R_L *of* $+\Delta R_L$ will result in a new output pressure $P_{os} + \Delta P_{o2}$. Also, for a change in P_i of $+\Delta P_i$ there will be a change in output pressure of $+\Delta P_{o3}$. These new values of the equation variables are substituted into Equation 18 and all coefficients of like terms are collected. If these changes are kept small, all squared Δ terms may be assumed much less than unity and can be neglected. By the principle of linear superposition the total change in output pressure may be considered to be the sum of individual changes or

$$\Delta P_o = -\Delta P_{o1} + \Delta P_{o2} + \Delta P_{o3} \qquad (19)$$

For these assumptions the following expression may be obtained:

$$\begin{aligned} R_L P_{is} + R_L \Delta P_i + \Delta R_L (P_{is} - P_{os}) = \\ R R_L Cs P_{os} + \Delta P_o (R R_L Cs + R + R_L) + \\ R P_{os} + R_L P_{os} + \Delta R P_{os} \end{aligned} \qquad (20)$$

In order to make use of the small perturbation method of linearization, the system has been assumed to be at rest at some steady-state level before it is disturbed. During steady state these conditions are satisfied.

$$R_L P_{is} = R P_{os} + R_L P_{os} \qquad (21)$$

and

$$R R_L C s P_{os} = 0 \qquad (22)$$

Therefore, the linear differential equation expressing the dynamic characteristics of the pressure process for small distrubances becomes

$$\begin{aligned} R_L \Delta P_i + \Delta R_L (P_{is} - P_{os}) = \\ \Delta P_o (R R_L Cs + R + R_L) + \Delta R P_{os} \end{aligned} \qquad (23)$$

Equation 21 can be represented in block diagram form as shown in *Fig.* 12.

Suppose that the performance of this process is to be evaluated in a control system where changes to the setpoint of the controller are to be made. In order to make this evaluation, the response of the output pressure for changes in the control valve resistance must be obtained. For this condition of operation P_i and R_L can be assumed to be constant and the transfer function of the process for changes in the control valve resistance is obtained directly from the block diagram of *Fig.* 12. By inspection the transfer function becomes

$$\frac{\Delta P_o}{\Delta R}(s) = -\frac{P_{os}}{R_L - R} \left[\frac{1}{\frac{R R_L}{R_L + R} Cs + 1} \right] \qquad (24)$$

The minus sign is due to the fact that an increase in R causes a decrease in output pressure. Note that the steady-state gain is a function of the level of the output pressure as would be expected for the assumption of linearity.

In order to obtain the actual transient response of the process, the circuit parameters must be obtained from the physical configuration of the sys-

Fig. 10—Flow-pressure characteristics of V-ported valve. At a mean flow of 300 lb per min and at 80 per cent valve opening, for a change in differential pressure from 30 to 50 psi, the assumed linear resistance is 0.133 psi per pound per minute or an error of approximately ±15 per cent

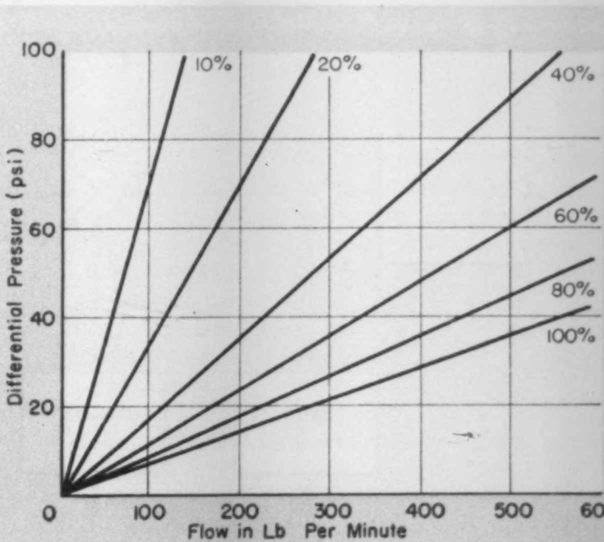


Fig. 11—Flow-pressure characteristics of the process load. Comparison between these characteristics and those of *Fig.* 10 demonstrates the difference in analysis between electrical resistance and pneumatic pressure drop through a valve

tem. The process being analyzed has these physical characteristics:

Volume of tank = 50 cu ft
Temperature of air = 61 F = 520° Rankin
Steady-state ΔP across control valve = 40 psi
Steady-state flow = 300 lb/min.
Steady-state output pressure = 60 psi
Steady-state supply pressure = 100 psi
Gas constant for air = 53.3 ft-lb/lb − °F
Reference pressure = 14.7 psi

By Equation 13 the equivalent capacity is equal to

$$C = \frac{V}{rT} = \frac{50 \times 144}{53.3 \times 520} = 0.26 \text{ lb/psi} \qquad (25)$$

By definition

$$R = \frac{40}{300} = 0.133 \text{ psi/lb/min} \qquad (26)$$

and

$$R_L = \frac{60}{300} = 0.2 \text{ psi/lb/min} \qquad (27)$$

Therefore,

$$\frac{R\,R_L}{R + R_L}\,C = \frac{0.2 \times 0.133}{0.2 + 0.133} \times 0.26 \times 60 = 1.25 \text{ seconds} \qquad (28)$$

which is the effective time constant of the pressure process at this particular operating level. Also,

$$\frac{P_{os}}{R + R_L} = \frac{60}{0.2 + 0.133} = 180 \text{ lb/min} \qquad (29)$$

For a 10 per cent step decrease in the valve resistance

$$\Delta R = -\,0.1 \times 0.133 = -\,0.0133 \text{ psi/lb/min} \qquad (30)$$

so that the input change is $\Delta R = -\ 0.0133/s$.

Equation 24 now becomes

$$\Delta P_o\ (s) = 2.4 \left[\frac{1}{s\,(1.25\,s + 1)} \right] \qquad (31)$$

From a table of inverse LaPlace transforms the change in output pressure as a function of time is found to be

$$\Delta P_o\ (t) = 2.4\ (1 - \varepsilon^{-0.8t}) \qquad (32)$$

This equation plotted as a function of time, *Fig.* 13, is the transient response of the process for a 10 per cent change in valve resistance at an operating level of 60 psi.

Response of the process for a change in supply pressure can be determined in exactly the same manner. The change in output pressure for a 10 per cent step change in supply pressure as a function of time can be found to be

$$P_o\ (t) = 6\ (1 - \varepsilon^{-0.8t}) \qquad (33)$$

Equation 33 is also plotted in *Fig.* 13 as a function of time. Note that the only difference in response is the steady-state gain which is expected since the process possesses only a single energy storage element.

Curves of *Fig.* 13 illustrate the transient response of the process for various step disturbances to its parameters. Curves of this type define the operation of the process and may be used in evaluating its design. However, the response of the complete control system of which the process is an integral part has to be obtained before an evaluation of the control system can be made. The block diagram and transfer function obtained from the analysis can be combined with the transfer function of other components in the loop to yield the response of the complete control system.

Analysis of the pressure process illustrates a procedure which may be followed in analyzing

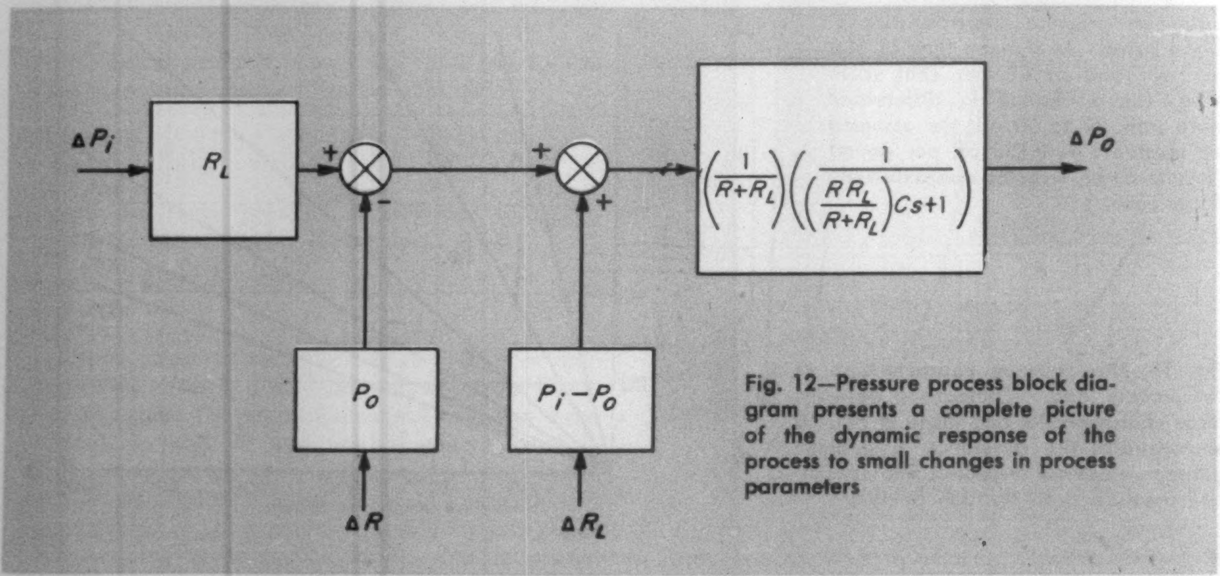

ΔP_i
R_L
+
−
+
+
$\left(\frac{1}{R+R_L}\right)\left(\frac{1}{\left(\frac{RR_L}{R+R_L}\right)Cs+1}\right)$
ΔP_o
P_o
$P_i - P_o$
ΔR
ΔR_L

Fig. 12—Pressure process block diagram presents a complete picture of the dynamic response of the process to small changes in process parameters

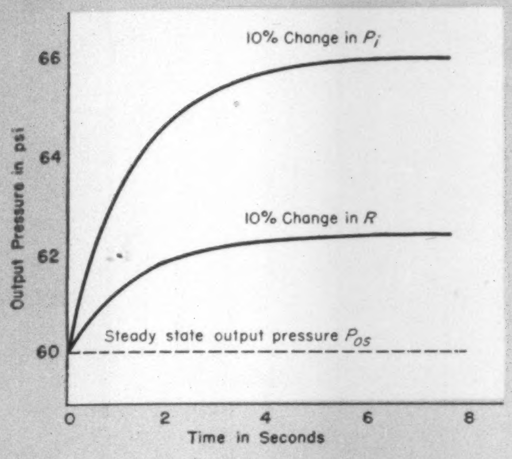


Fig. 13—Transient response of pressure process to step inputs. Equations 32 and 33 are plotted showing response to step changes in valve resistance and supply pressure respectively

physical systems. While it is true that the response obtained is not an exact solution, it nevertheless defines the operating characteristics within certain limits. Analyses of processes are often based on ideal parameters which serve to indicate the best performance that can be obtained. This ideal performance may later be used as a criterion for evaluating specific systems designed for the application.

Processes analyzed in this discussion have, for purposes of presentation, been confined to simple, single capacity systems. However, the techniques used may be applied equally well to more complicated physical systems. It is true that the mathematical equations obtained for more complicated systems will necessarily become more complex and will in many cases require the use of electronic computers for their solution. However, this need not detract from the techniques presented, since their greatest utility arises from the systematic approach to the problem afforded by their use. In fact the more complex the process the greater is the need for a systematic approach to the control system design. This is the best single justification for the use of feedback control techniques in the design of process control systems.

The next article of the series will point out the engineering needs of future automation developments. The basic thesis will be that these predictions may be realized only through a systematic approach to control system design.

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Electronic Tube Substitute

NEW ELEMENTS for electrical and electronic circuits continue to strengthen and widen the theoretical range of application in the field of automation. Typical is the Magnistor, a product of the Potter Instrument Co., which is stated to have the advantages of transistors and magnetic cores without the attendant disadvantages.

Magnistors are small saturable reactors having unique shapes and flux paths. They are divided into two general classes described as "transient" and "permanent." The transient type class has no memory while the permanent or two-state class will remember its set or reset condition indefinitely even if all power is removed. The simplest form contains two windings wound on special ferroceramic material. One winding called the signal coil is used to carry a sine wave signal in the range from 100 kilocycles to 15 megacycles or pulses having a repetition rate from 0 to 10 megacycles. By varying the dc current applied to the second winding (called the control coil), the impedance of the signal winding to the carrier frequency or pulses can be varied over a ratio as high as 500 to 1, if desired. Power levels in the range of microwatts to tens of watts can be controlled.

The permanent class Magnistor basically contains three windings on a special ferroceramic core. One is a signal winding similar to that used in the transient class. The other two are control windings normally designated as set and reset coils. The signal winding has two possible impedances—a low impedance if the set coil has previously passed a specified minimum current in either direction and a high impedance if the reset coil has previously passed a specified minimum current. Either condition persists until the other is established regardless of the presence or absence of energy anywhere in the system.

Magnistors are used to gate, switch, amplify, count and record as well as to form logical arrays for adding, subtracting, shifting and other computing functions. They have been developed to meet the need for a nondeteriorating device capable of performing the above functions at speeds comparable or in excess of electronic devices. They are different from other components in that they perform functions previously only simulated by electronic tubes and transistors. In addition, they have indefinite shelf life, the controlled and controlling elements are independent, they are undisturbed at temperature ranges attained in commercial and military equipment and are inherently rugged in construction. In addition, they can be designed to operate over a wide range of power levels, require no warm-up time and are supplied in hermetically sealed metal cases which plug into standard 9 pin sockets.

The principal application of these new magnetic elements will be in high speed computers, business data handling systems, control systems, high speed counters and magnetic tape systems.

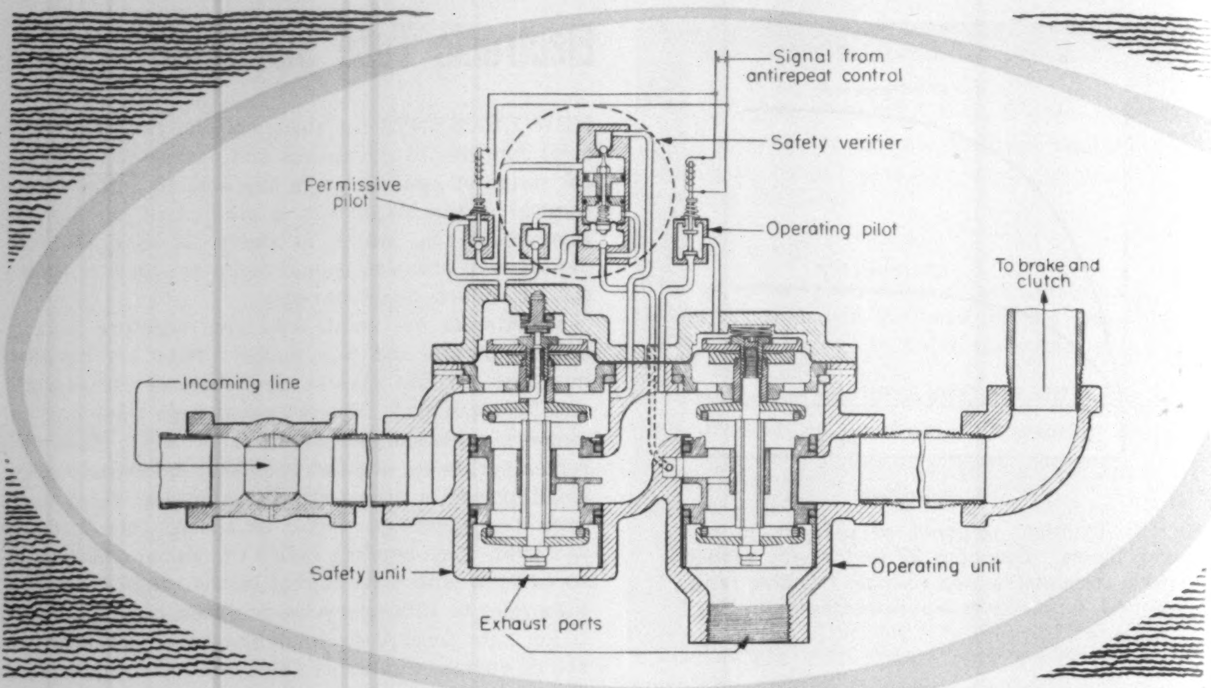


Fig. 1—Details of protector valve shown installed on semi-automatic press. Control station on left upright contains key-operated electrical test circuit which simulates effect of a jammed pilot unit which should cause safety valve to operate for a complete safety spot-check of unit

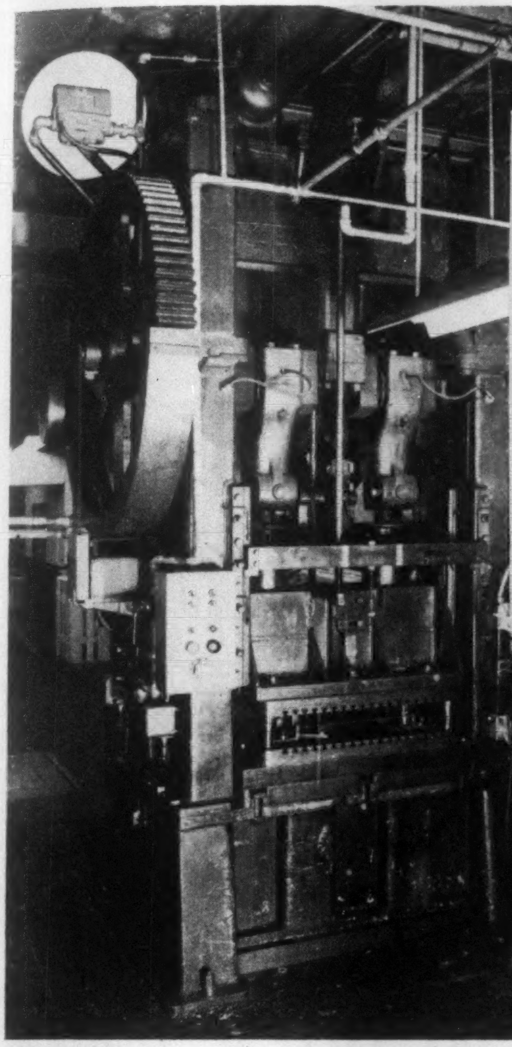
INCREASED SAFETY FOR AIR OPERATED PRESSES

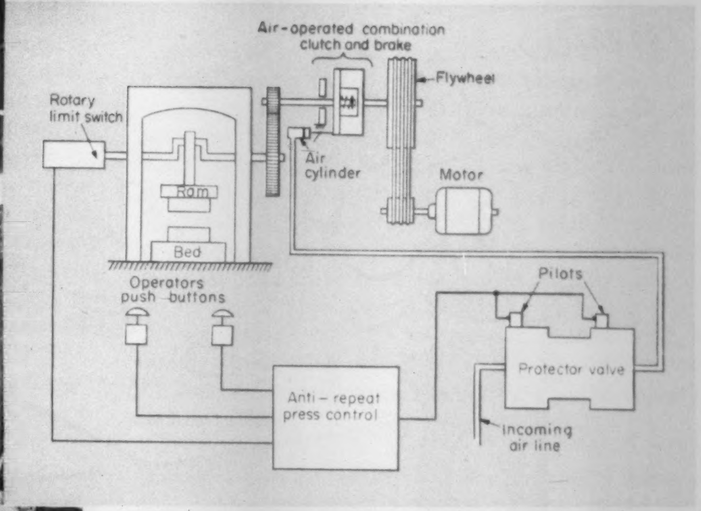
NEED for safety does not necessarily change in those instances where an iron hand replaces a human hand—only the emphasis changes. Primary need for protection of the operator is replaced by need for protection of equipment, material and continuous operations.

In developing improved automatic protection for large air-operated presses, engineers at the Clark Controller Co. developed the unique approach of designing a valve which would not allow operation of a press at all, whether or not conditions were safe, and then proceeded to modify this system only enough to permit desired operating action when conditions were safe. The danger to be guarded against is descent of a press ram at an inopportune moment. Safety is obtained by preventing the press ram from moving by keeping air cut off from the clutch and brake.

Main elements of the safety valve, *Fig.* 1, are the operating unit, operating pilot, the safety unit, permissive pilot and a safety verifier. The operating unit controls movement of the press ram under direction of an antirepeat control, in the Clark system an interlocking electrical circuit requiring operators to depress run buttons with both hands before a signal is sent to the operating pilot. When the operating pilot receives a signal from the control, the operating unit admits air pressure to the load —the press clutch and brake—causing the ram to move. When a signal from a rotary limit switch synchronized with ram movement ends, the operating unit cuts off pressure and opens the load to exhaust. This stops the ram in position for the next stroke. The safety unit is also capable of stopping the ram by cutting off air pressure and opening the load to exhaust.

In operation, a feedback line connects the load to an area above the safety unit diaphragm, so that substantially the same pressure exists in both places. This means that the very act of admitting





pressure to the press and brake to start the ram moving will at the same time admit enough pressure to the safety unit to cause it to stop the ram.

The unit is made operative by the permissive pilot which cuts this feedback line off from the safety unit. The permissive pilot, like the operating unit pilot, is actuated by an electromagnet and by the same signal as the operating pilot. Thus it operates with each stroke of the press. Each time the antirepeat control signals a safe condition, and the operating unit admits pressure to the load and the feedback line, the same safe signal causes the permissive pilot to block the feedback line off from the safety unit. When there is no safe signal, the permissive pilot allows pressure in the feedback line to reach the safety unit. If enough pressure to operate the clutch and brake exists in the line at this time, it will also operate the safety unit.

Most potential faults are thus rectified by the permissive pilot action. The operating unit, for instance, could fail to fully cut off line pressure due to some unusual mechanical condition. This could admit enough pressure to engage the clutch and release the brake. But the pressure would also be enough to operate the safety unit, through the feedback line.

The protector unit also includes a safety verifier which is a valve with a floating piston, normally kept motionless by a balance of pressures. In effect, the piston compares pressure at each end of the feedback line. If it finds them the same, except for minor pressure drop in the line, it remains in balance. But if, for example, the permissive pilot remains closed after a safe signal ends (this would erroneously indicate a safe condition for the next stroke) the verifier will trap pressure at its end of the feedback line, while at the other end the brake and clutch are open to exhaust. This imbalance of pressures will move the safety verifier piston, uncovering a port which permits pressure to the area above the safety unit diaphragm, taken from the incoming air line. This will operate the safety unit and stop the press.

The safety valve is completely stable and is not subject to operation due to transient or minor conditions. However, a pressure leakage approaching that necessary to keep the clutch engaged will positively and quickly cause the safety unit to function.

This protector valve obsoletes the use of two valves in a system in an attempt to gain optimum safety. It is a definite improvement in that only the operating unit moves with each stroke of the press. The safety unit stands by, ready to function only if the operating unit fails. The safety unit is not subjected to the wear of regular operation, and does not continually duplicate the cycle of the operating unit. Thus the possibility of simultaneous failure is virtually eliminated.

BUSINESS AS USUAL—
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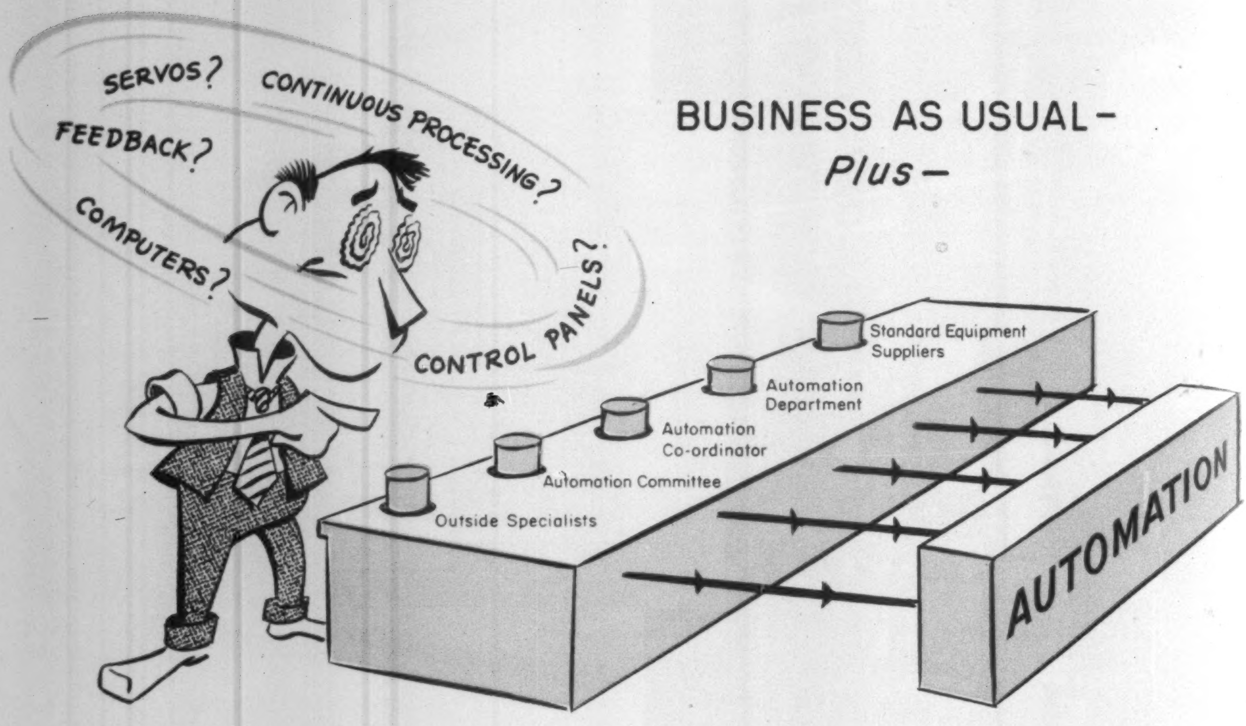
SERVOS?
CONTINUOUS PROCESSING?
FEEDBACK?
COMPUTERS?
CONTROL PANELS?
Standard Equipment Suppliers
Automation Department
Automation Co-ordinator
Automation Committee
Outside Specialists
AUTOMATION

Choosing the best automation organizational arrangement is not difficult when facts are available

By C. E. EVANSON
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ORGANIZING THE AUTOMATION PROGRAM

To undertake the task of automating its business operations management may set up an organization within the company and supplement it through working arrangements with consulting automation specialists

ONCE A COMPANY has decided to proceed with automation or partial automation for its plant, the next important step concerns planning the program of automation. How to do this poses a problem to top management because it is management's decision as to the type of organization and working arrangements which will be in the best interests of the company. Management is naturally concerned with the ultimate objectives and results It desires to carry out the program in the most practical and economical way possible. Further, it wants to have full benefit of the best and latest automation know-how available.

There are a number of possible ways of organizing or of obtaining assistance in carrying out an automation program. Following are the ways most frequently mentioned in automation circles:

1. Executive committee
2. Executive co-ordinator (automation engineer)
3. Automation engineering department
4. Counsel of suppliers
5. Counsel of automation consulting engineers

Company Committee

A first possibility, the formation by management of an executive committee, seems to be a very logical step. In many instances of a new problem or project, we have seen management appoint a committee almost automatically regardless of the nature of the problem or project. Some times the executive committee arrangement is ideal, but whether it is the best way to organize for the complexities and ramifications of automation can be questioned. True, forming the executive committee is not costly since participation in such a committee usually is just an added assigned responsibility. However, this very fact can contribute to the downfall of the functioning of the committee, because as we have already seen, automation is so widespread and far-reaching in scope that everyday departmental interests, lack of time, and the usual delays in action may actually hamper the progress of the committee.

Several months ago the president of a large company became interested in automation and immediately appointed three vice-presidents to an automation committee to study the subject and to determine how its principles could be applied to the company's operations. Unfortunately these men, experts in other subjects, had not even heard of automation. Furthermore, they were very busy with their primary responsibilities which required considerable travel. The result is that to date no action of any significance has been taken and it is doubtful that appreciable accomplishments will be forthcoming under this arrangement.

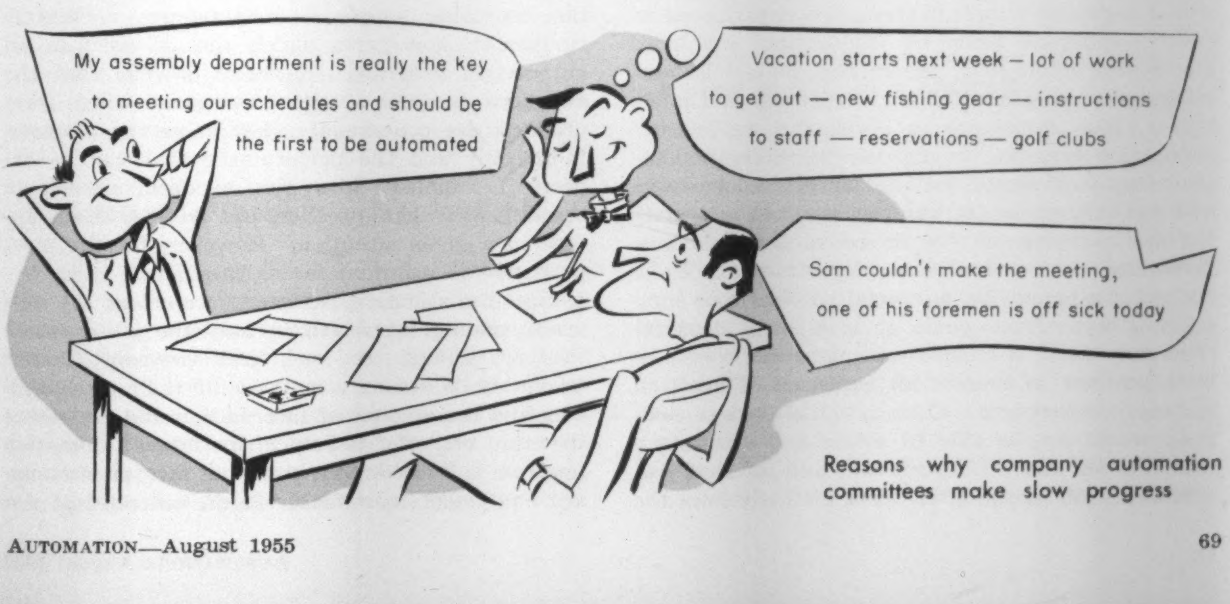
Another important point to watch for in the executive committee plan is that adequate leadership must be available. In a large company this may not present much of a problem, but in the average-sized company there are probably not too many, if any, executives available who have sufficient experience in automation to provide the leadership that is necessary. Another factor to consider in the committee plan is the fact that primarily the committee members have other responsibilities which take prior attention unless top-management has laid out definite programs and deadlines to be met. If this cannot be done, the automation program will probably suffer as illustrated in the previous case history.

▶ Automation Executive Co-ordinator

A second method of organizing, and carrying out a program for automation is the nomination of an executive co-ordinator or automation engineer. This also has the advantage of being done quickly and simply; and, on the surface, of not being too costly or time consuming for other key executives and engineering personnel. Management would no doubt desire to make this position a full time responsibility, with the appointed individual acting as a co-ordinator of the automation plans and also acting as a clearinghouse for information. He would, no doubt, work with other department heads as well as outsiders in formulating detailed plans to carry out an overall program of automation.

However, the problems here are several. In the first place, there is the difficulty of finding someone within the organization who is fully qualified to be assigned this position of responsibility. In some cases where a company desired to develop one of its own promising men for this position, we have suggested our training program to supplement the new co-ordinator's own knowledge so that his adjustment period would be easier and more complete. We have thus helped to make this new position active and productive in a relatively short time.

It is also a problem to bring in someone from the outside because of the limited number of qualified automation experts available in the field. Next, if a company man is assigned to this new position, there is the problem of point of view, attitudes, and general relationship with others with whom the individual has worked in the organization in other capacities. Since an objective point of view is important, the hiring of an automation expert from the outside would have the advantage of freedom from preconceived concepts either departmentalwise or personality-wise. Therefore, the permanent employment of an executive having the necessary


My assembly department is really the key to meeting our schedules and should be the first to be automated
Vacation starts next week — lot of work to get out — new fishing gear — instructions to staff — reservations — golf clubs
Sam couldn't make the meeting, one of his foremen is off sick today

Reasons why company automation committees make slow progress

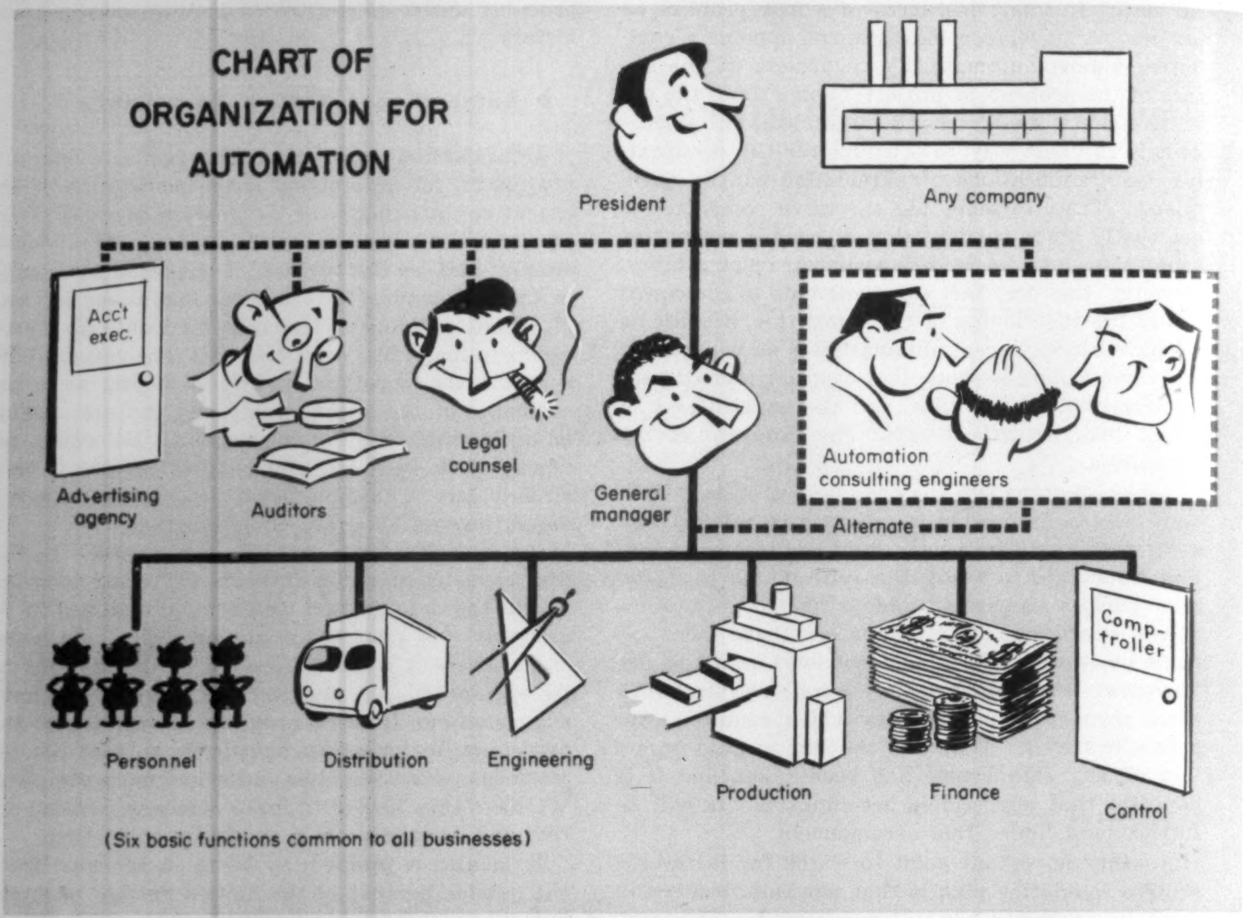


CHART OF ORGANIZATION FOR AUTOMATION
President
Any company
Acc't exec.
Advertising agency
Auditors
Legal counsel
General manager
Automation consulting engineers
Alternate
Personnel
Distribution
Engineering
Production
Finance
Comp-troller
Control
(Six basic functions common to all businesses)

qualifications and an unbiased attitude would be worthy of consideration.

▶ Complete Department Requirements

Another way of setting up and carrying out a program of automation is by establishing a complete automation engineering department. This would necessarily include specialists experienced in several different fields of engineering, involving electronics, hydraulics, pneumatics, materials handling, processing and tooling, structures and plant layout, plus experience in developing automation production systems. In addition the automation engineering staff should include experienced business and methods engineers who can assist in interpreting and carrying out the interests of the finance, personnel, control, and sales departments. While the establishment of a special automation engineering department would be ideal, it is doubtful that more than a handful of companies would be in a position to finance all expenses of such an elaborate department. Certainly, the average company would not be able to obtain and maintain a complete automation department, and for that reason while this is one of the best methods from the technical viewpoint, it is one of the least popular methods of organizing and planning for automation.

▶ Valuable Assistance from Suppliers

A fourth possibility of organizing and obtaining help to carry out an automation program is to utilize the advice and information available through the reputable suppliers of standard machinery, equipment, and parts which can be used in an automation program. It seems obvious that the suppliers can offer excellent assistance where their products are concerned. They know the products thoroughly and the performance that can be expected. Suppliers also give excellent service in showing how their products can be used to advantage in a given situation. However, for the most part, that is about as far as they go.

Actually, standard equipment suppliers are naturally mainly interested in only the items which they are selling. As such their viewpoint, understandably, is strongly in favor of their own products and the amount of information and assistance that they can offer to help with a broad automation program is limited. As a matter of fact, most standard equipment manufacturers do not attempt nor

TOOLS OF THE AUTOMATION CONSULTANT'S TRADE

Broad and specialized experiences

Company files and library
plus
other ready sources of pertinent information

Collaboration with other consultants when deemed advisable to further the interests of a client

Miscellaneous:
Fresh viewpoint — New ideas from allied lines
New ideas from radically different fields
Impersonal approach — Unbiased attitudes
100 % concentration on project

profess to have the time or staff available to give professional engineering advice or to actually help plan a complete automation program. However, it is when a program has been established and the company is actually in the details of carrying out portions of the program, that the standard suppliers should be consulted for specialized knowledge concerning their particular products and how they will perform in the line. From the foregoing it should be apparent that companies which are considering automation should not and cannot expect the standard equipment suppliers to do engineering planning or systems design beyond a reasonable point where their individual product is concerned.

Automation Specialists Are Available

A fifth possible way of organizing or obtaining help for your automation program is the retaining of consulting engineers experienced in automation. Some of the consulting firms have already made interesting and result-producing contributions to automation. Because of their know-how and objective viewpoint, they are in an excellent position to render valuable service to the manufacturer who needs help in planning ahead. The one possible disadvantage that at first may seem to be evident has to do with the cost of bringing in expert professional talent and service. In most instances, however, specialized professional service pays for itself many times over through proved procedures that save time and money in the long run.

An established consulting engineering firm usually has a complete staff of specialists in each of the various areas of automation, who can quickly and efficiently assist with the planning and carrying out of an automation program. They know how to conduct automation appraisals and how to determine practical automation to fit the individual need. Further, they usually have at their finger tips the vast amount of information required. For example, over the years our own firm, in addition to gaining practical experience in the field of automation, has dveloped a complete engineering and automation library. This has proved to be invaluable in helping our staff plan and coordinate the development of balanced automation systems for clients with a minimum amount of time and effort expended. This need for a complete staff equipped with technical resources is one of the main reasons why the manufacturer who prefers or endeavors to set up a complete internal department finds in the long run that to do so is very expensive.

In reviewing the possible ways of organizing for automation it is difficult to make a general statement as to the best plan which will suit all companies. Obviously, each company has individual preferences and conditions which have a bearing upon the type of organization which is established. Needless to say, the planning and carrying out of any automation or partial automation program requires the best possible organizational setup. It will necessarily have to carry the weight and respect of the top executive in the organization because of the relationship of automation to all of the other functions of the business; namely, control, finance, engineering, production, distribution, and personnel. Because of this interrelationship, all policies and programs should be under the direct cognizance and direction of top management. Any lesser stature of the automation organization will only result in slow progress, confusion, misunderstanding, friction, and loss of time and money.

How to Set Up a Program

We have found through our experience that one of the most expedient, most economical and most direct methods of approaching this problem is along the following lines: First, it is recommended that an executive automation co-ordinator be appointed with a suitable title and the authority to command the respect required to carry out the overall aims and objectives of an automation program. Naturally, the exact position may vary from company to company, but it should be recognized that it is an important function. That's why in most cases, this position should carry the title of vice president, or at least a title not removed more than one step from the vice president's level. The automation co-ordinator should report to the president from a staff position as illustrated in the accompanying organization chart, and he should not report through any of the heads of the primary functions of the business organization. Realizing the breadth and depth of the subject, its requirements, and its potentials, we can appreciate the reason for this. The specific interests of the primary operating functions will naturally be considered, but they cannot influence or affect the automation program except as through the interpretation of the general manager.

The staff of an automation co-ordinator need not be elaborate. As a matter of fact, an executive assistant and limited clerical or secretarial help should suffice. Actually, his office will be a clearinghouse of information for the various operating divisions in addition to co-ordinating the various departments and their activities in the automation program.

By establishing an automation co-ordinator, the company will gain an important advantage of building a leader within the organization. Because of the high caliber of the individual whose services will be required in this position, it is likely that he will already have the leadership qualifications, but the building of executive timber and the bringing out of leadership qualities is an unending process even at the top level of most businesses. There is always room for growing and improving and that is certainly true of an executive in the new field of automation.

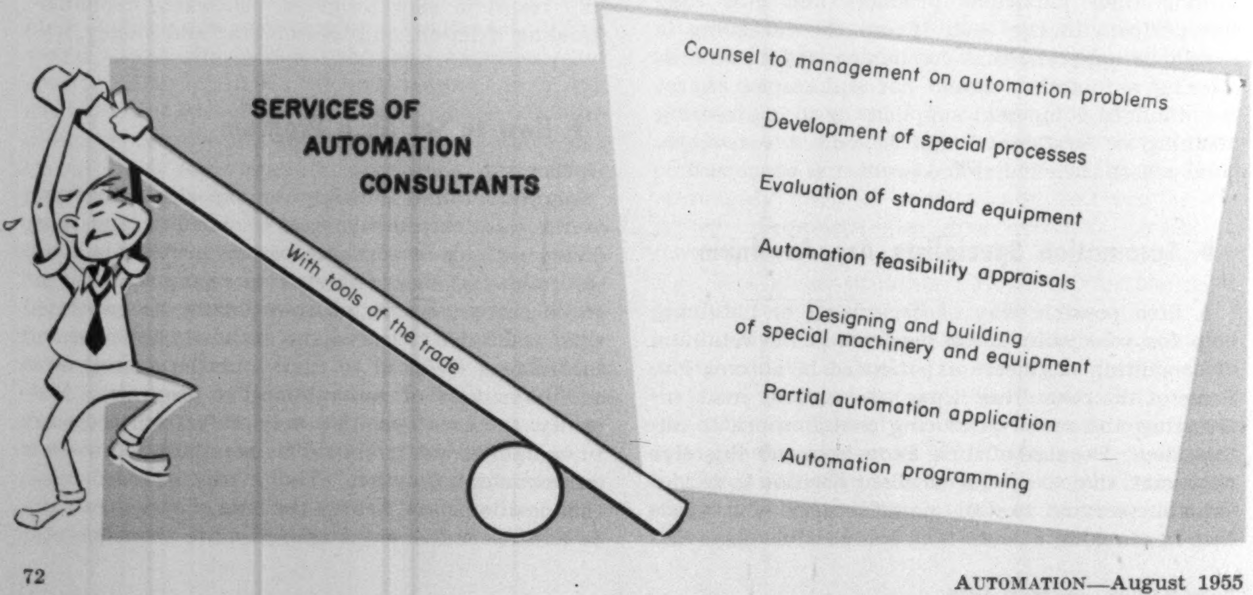
Once the automation co-ordinator's office is organized, the procedure that the company will then follow depends upon the availability of personnel experienced and qualified in automation. It is recognized that the know-how of specialists will be required—specialists not only in the technical sense, but also in the business or economic sense. Furthermore, these specialists not only should be able to draw upon their individual experience in automation but also should have a comprehensive source of information readily available to supplement their own knowledge and talents.

Automation Studies Pay Off

One of the first actions of the automation specialists will be to conduct appraisals or studies to determine which production phases of the company are ready for and suitable for automation. It may be determined that the entire operation can be automated—it may be determined that only certain factory or office departments or functions should be automated—and, of course, in rare instances it may be found that no part of the production process is ready for automation or even partial automation.

Only after the complete initial technical and economic studies are concluded can the overall program be established. Once this is done the next steps will be the carrying out of the program. It will be a question of working out details on the drawing board—of determining the availability and adaptability of standard equipment—of actually designing and building special machinery and equipment which may be required—and of training personnel how to think and act for automation.

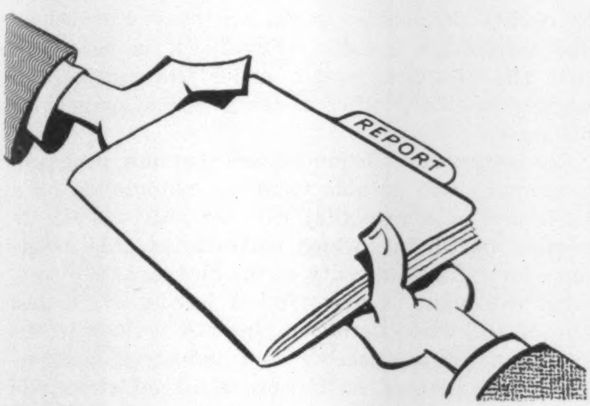
Because of the previously mentioned disadvantages and problems involved in building a complete automation department, the average company will find it beneficial to consider supplementing the automation executive co-ordinator with an experienced automation consulting engineering firm.


SERVICES OF AUTOMATION CONSULTANTS
With tools of the trade
Counsel to management on automation problems
Development of special processes
Evaluation of standard equipment
Automation feasibility appraisals
Designing and building of special machinery and equipment
Partial automation application
Automation programming

▶ Specialists Can Help Management

In the first place specialists are an excellent source of the experience and talent required. Having already applied the principles of automation and having seen them in actual practice, as well as having designed automation production systems, the automation consultant will have a wealth of automation background and information which will save manufacturers a considerable amount of time and money.

The progressive automation consultant will have a large library properly organized and catalogued to help the staff analyze and solve automation problems. For companies not to take advantage of this is, of course, an economic waste. While professional ethics will prevent the consultant from revealing actual details of another client's automation program, nevertheless, the experience and know-how gained will be indirectly available just as experience gained by anyone in any field always adds to his total storehouse of knowledge. We have found, for example, that we have been able to cross-pollinate workable ideas from one industry to another with considerable success and benefits for our clients.



A complete report of findings should be prepared and submitted in one package

Another and equally important reason why a consulting firm of automation engineers should be considered is the element of time. The experienced firm already has established procedures for conducting automation appraisals and for determining if and how automation can be applied to a given plant. Therefore, the staff can move quickly and directly with a minimum loss of time and effort. In the long run this will mean savings to the manager in establishing and carrying out his automation program.

One of the most important advantages that the consulting firm can offer to the automation co-ordinator is that of an impartial, unbiased viewpoint. The company's executive will find this invaluable in helping to keep his sights properly aligned and to keep the various departments and functions of the business in proper focus. Professional consultants are trained to maintain this unbiased viewpoint and to be objective about any and all problems on which they are consulted. This is even more important in automation because the subject is more far-reaching and the potentials and ramifications are much greater than those of an individual problem.

A good example of how this works is the way in which standard equipment is recommended to a client. When it is determined that standard equipment will satisfy a technical requirement, a consultant must then survey the market, study the various competitive units available, and then decide upon or recommend for decision the best equipment to meet the client's needs. Similarly, the automation consulting firm has no reason to show preference within the organization, such as toward the engineering or production departments; nor would the consulting engineers be unduly influenced by financial control desires or sales department preferences. Their primary contribution is to assist in planning, designing, and producing a balanced automation system for the profitable good of the organization.

▶ Look Ahead—Think Big

Another way that the consulting firm can assist management through the automation co-ordinating executive is by stimulating vision and advanced thinking. Certainly, in any planning and development program that has the far reaching aspects of automation, no manufacturer can underestimate the need for looking into the future. The trained consultant must constantly be alert to probable conditions and developments, five, ten, and more years ahead. Many times management is so occupied with problems of the present and immediate future that it does not have the time to anticipate trends and markets, technological developments, etc., in the years ahead.

Recently we were consulted on a manufacturing problem wherein the client wanted production speeds of 150 to 200 units per minute to match its competitor's production rate. During our study, we asked: "Why do you want to follow your competitor? Why not think in terms of 600 to 800 units per minute and move out in front?" The answer was a weak "no"—the engineering and production people felt that was moving too fast. Yet, less than a year later, another competitor has developed the means to increase production to over 700 units per minute and stands an excellent chance to gain the bulk of the present and potential market. The latter company had the rare insight to look far ahead and the courage to think and act big.

While it is true that definite predictions cannot be made the trends are indicated and an analysis of the future in terms of present accomplishments will give some idea as to what technological developments can be expected. In other words, the consultant can supply a practical approach to the future—and this will be reflected in the development of a program which is not a dream, but which is sensible and consistent with reasonable anticipation.

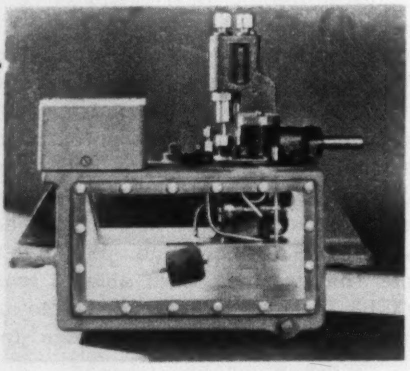
In summary, while we feel from experience that one of the best methods of approaching automation is through the establishment of the automation executive co-ordinator, supplemented by a professional automation consultant, the final decision of organization remains, of course, in the hands of management. But the important thing is that it is not too early for management to take immediate action to have automation specialists study and evaluate the product, production, engineering, personnel, distribution, and all factors which relate directly or indirectly to an automation program. A complete report of findings should then be prepared and submitted in one package in order to assist management to understand the problems and make prudent decisions. Even if such a study revealed that automation would not be wise or practical for a company (which is highly unusual), the time, effort and expense will still be worthwhile. In other words, to learn what not to do is often as important as learning what to do.

In a majority of the cases subjected to study and analysis, automation or partial automation will be found to have definite possibilities. The big problem then, is to set up a plan and program for further detailed studies to pin-point the best ways of applying the automation techniques. This plan or program will be influenced largely by the high cost areas in the factory, office and warehouse because these are the places where automation will pay for itself quickly.

The program should be all encompassing with a time schedule (based on economics and desires of management) for the completion of each phase of the program. There should be guide-posts for carrying out the program efficiently plus check-points for measuring accomplishments. Furthermore, the responsibilities for each phase of the program must be clearly defined to permit the most expeditious and worthwhile results. Finally, it is necessary that the program remain under the control and cognizance of the office of the president or general manager.

By setting up a balanced and dynamic program, a company will be able to install automation on a basis and at a rate that will not only sustain its present health but which will also provide assurance for future longevity of the business. No company will want to be guilty of having overlooked one of the most significant growth periods in the evolution of engineering and industrial achievements. Therefore, businesses in all industries will be wise to plan today for automation tomorrow.

AUTOMATIC UNIT PROVIDES UNIQUE LUBRICATION SERVICE



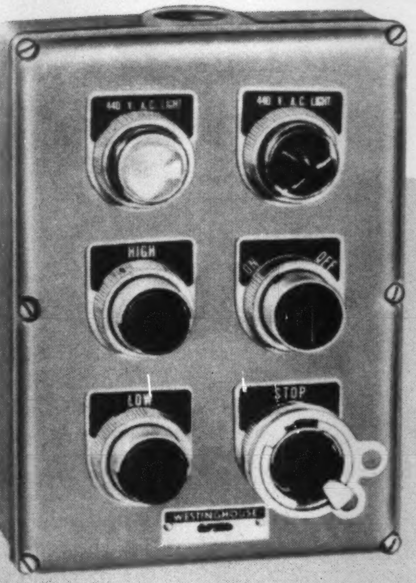
ORIGINALLY designed for automatic bottling machines, a line of lubricators has been developed by Bijur Lubricating Corp. for machines which require several methods of automatic lubrication from a single source. The single lubricator shown, equipped with pneumatic controls, provides continuous, cyclic and jetting lubrication. Oil flow for all three services is provided by one gear pump which is driven by the machine through built-in reduction gearing. Valving and by-pass mechanisms within the pump provide the means by which the three branches operate.

The continuous branch operates at low pressure controlled by a loading valve located between a by-pass and the main gear pump discharge. The oil is forced through tubing to the various points where it is distributed according to the individual needs of each bearing surface.

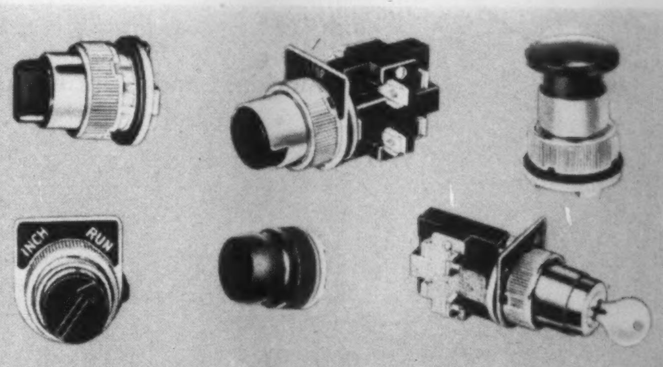
The cyclic branch operates at high pressure on a predetermined time schedule. A cam, driven by internal reduction gearing, actuates a timing valve at a predetermined frequency when the production machine is operating in the intermediate speed range; oil is forced into the proper tubing for the cyclic system. Units at each outlet point in this system insure proper oil distribution.

Jetting is accomplished by operation of a piston valve in the pump which permits oil to discharge through ports to the jetting line. This valve is actuated by a pneumatic cylinder which is in turn operated through a solenoid air valve controlled either by a timer or a pushbutton on the machine control panel. When the pneumatic cylinder is actuated, oil is forced through the jetting line to nozzles which spray oil into the part to be lubricated.

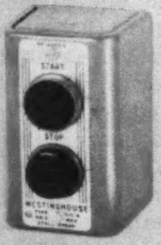
In addition to these features, this lubricator includes a float switch which first flashes a warning light when the oil level in the reservoir reaches the refilling stage, and if no corrective action is taken, shuts down the machine when the oil reaches the minimum safe level.



Westinghouse 6-Unit Oil-Tite* Control Station

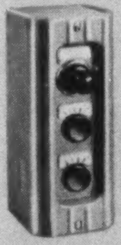


Standard Components Available



Standard Duty

Available in one, two and three unit stations.



Heavy Duty

Comes in a choice of from one to seven unit stations.

Pendent Type

In standard, heavy duty and Oil-Tite enclosures.

Special Service

Units for mining, steel mills, extra heavy duty.

Westinghouse control stations increase pushbutton flexibility

Industry's Most Complete Line offers a wide selection of components for every pushbutton application—standard duty, heavy duty, oiltight, pendent type and special service.

Standardized Components provide greater application flexibility—help you benefit from off-the-shelf shipments and smaller inventories. The simple combination of a few interchangeable component parts gives you the right pushbutton or selector switch for every application or service requirement.

*Trade-Mark

Enclosures for Every Application—surface or flush mounting, indoor or outdoor, water and dust-tight, oil immersed, die-cast gasketed oiltight, and pendent mounting.

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YOU CAN BE **SURE**...IF IT'S

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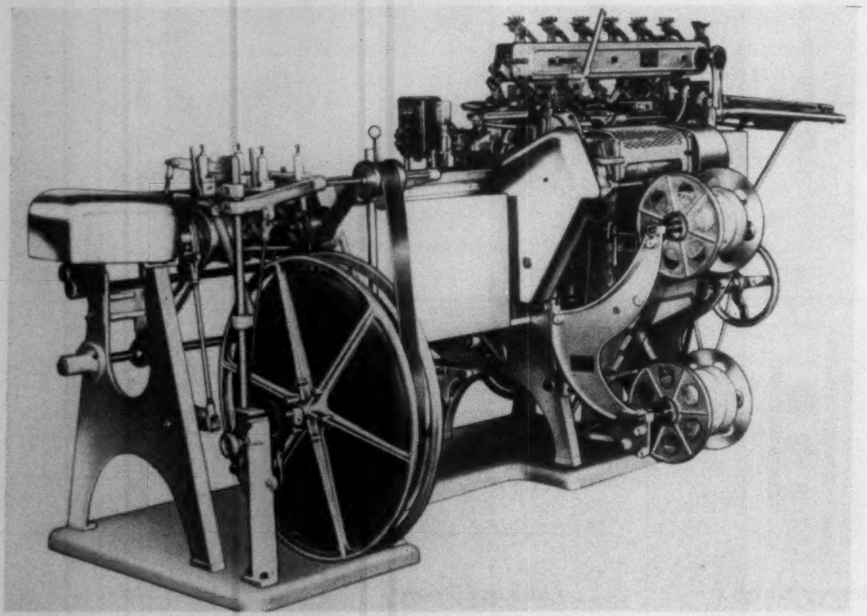
AUTOMATION new equipment

Machines and plant equipment designed for more automatic operations



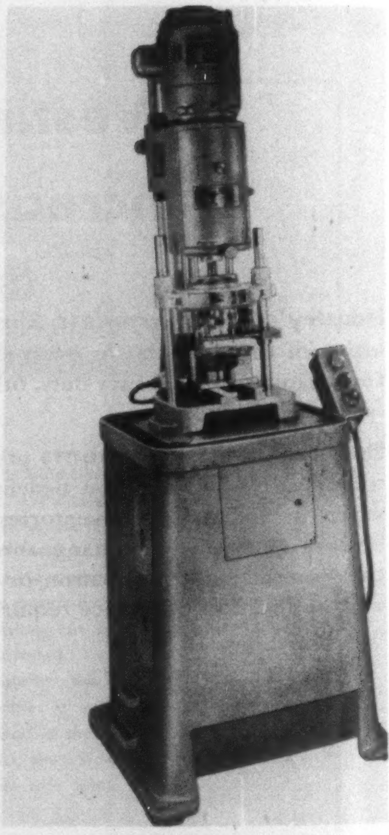
WRAPPING MACHINE

Designed to wrap irregularly shaped products as well as regular shapes in a square package, and with a die fold which allows all sealing on the bottom of the package, machine can wrap as many as 120 packages a minute. Either hand feeding or mechanical feeders can be used. The machine is driven by a ¾-hp electric motor. Overall dimensions of the machine are 45 inches high by 54 inches wide by 160 inches long. Range of packages that can be wrapped are from 11/16 to 4⅞ inches wide, 1⅜ to 7½ inches long, and ⅛ to 1¾ inches high. Where required, machine uses a 3 ft diameter roll of card stock, cutting and feeding into pockets or scoring, folding, cutting and feeding into pockets, thus forming a three sided boat or flat card. Product to be packaged is fed into machine pockets and product and boat or card are carried forward into wrapping area. Wrapper is then cut off to proper size from roll which is fed directly over the pocket. An elevator raises the boat or card and product into the wrapper where infold is completed. At the top of the elevator stroke a ram pushes the product forward completing the wrap. Wrapped product is then picked up by a moving conveyor which pushes it across sealing equipment onto the discharge tray. Among products handled by the machine are candy bars, ice cream bars, cupcakes, cookie and cracker sandwiches, and novelties including pencils, modeling clay, cigars, door hinges and cake decorations. **Lynch Corp.**, Anderson, Ind.

Circle No. 1 *on Reply Card*

TAPPING MACHINE

Self-contained, electrically controlled and operated device is designed for precision single and multiple spindle tapping or threading. Electricity is the only power required; no cams, air or hydraulic systems are used. Using forward and reverse electromagnetic clutches, machine needs no reversing motor and can be operated at high speeds. A built-in rheostat control mounted on the side of the machine permits the torque of the clutches to be regulated over a range of 0 to the equivalent of 2 hp, giving the machine the sensitivity required to protect small taps, and the power and torque needed to drive the larger taps. Since the clutches are energized within themselves, there is no end pressure on either lead screw or taps, thus producing a thread that is as accurate as the taps or dies being used. An external depth control knob allows the tap depth to be controlled to within ¼ turn anywhere within the maximum



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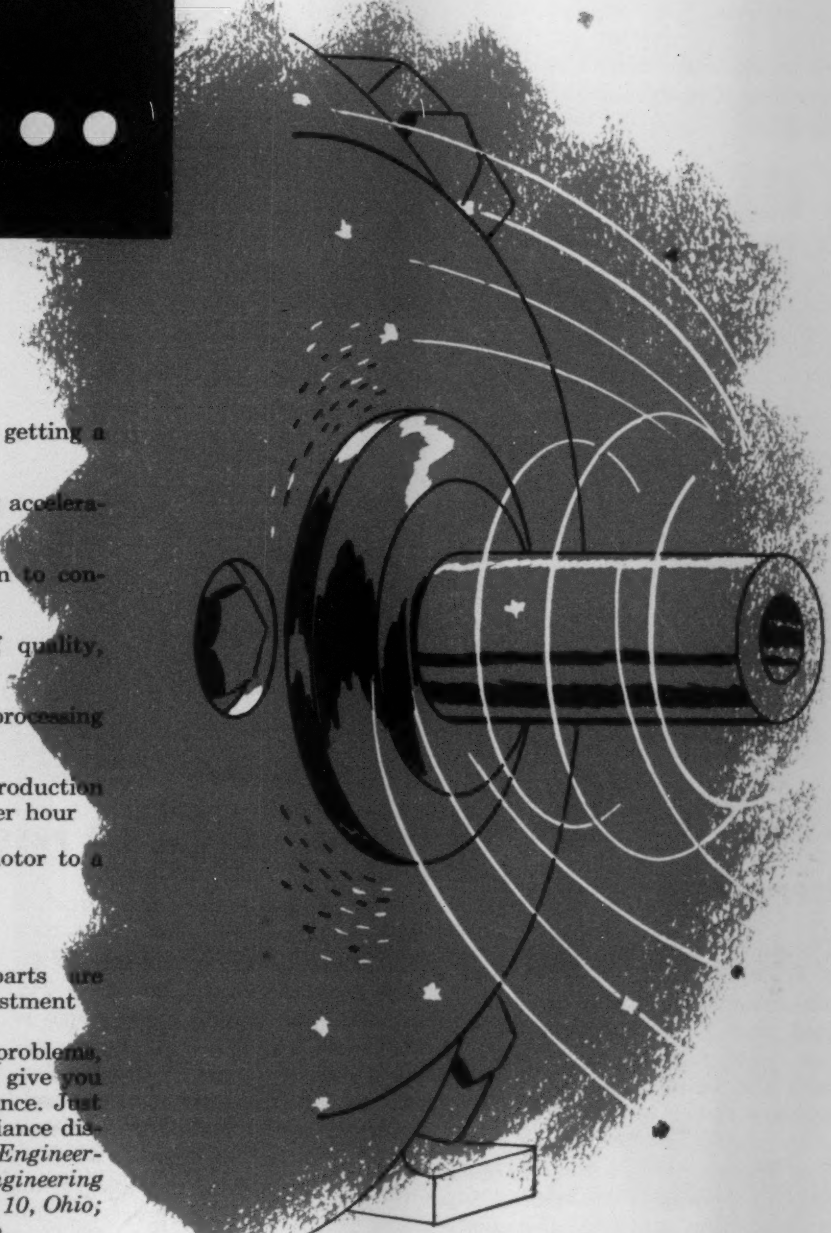

- You are spending too much time getting a tool to and from an operation
- You are having trouble controlling acceleration under tension
- You need a more precise operation to control scrap
- You need hair trigger control of quality, quantity and size
- You want to start and stop your processing line faster
- You would like to leave your production line virtually unattended hour after hour
- You require re-acceleration of a motor to a previous exact speed
- You want centralized control
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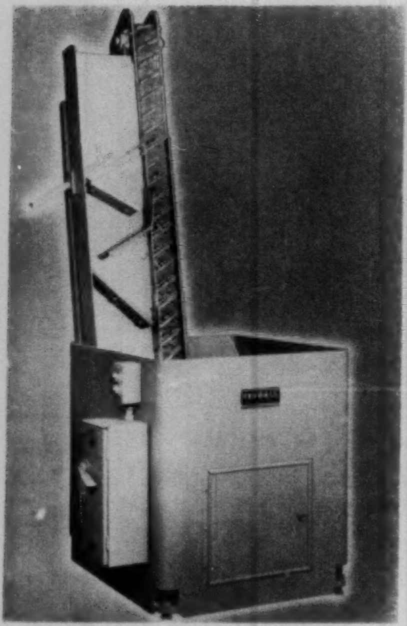
RELIANCE ELECTRIC AND ENGINEERING CO.

Builders of the Tools of Automation

stroke of 1⅞ inches. Lead screw which feeds the tapping head into the work runs in a special split lead nut. A variety of motor drives are available, including direct mounted fixed speed, direct mounted variable speed and direct mounted variable speed geared type motors. Machine can also be supplied with single or multiple pulley drives. Tap lubrication is provided by a coolant pump located in the base of the machine. **Ettco Tool Co. Inc.,** 594 Johnson Ave., Brooklyn 37, N. Y.

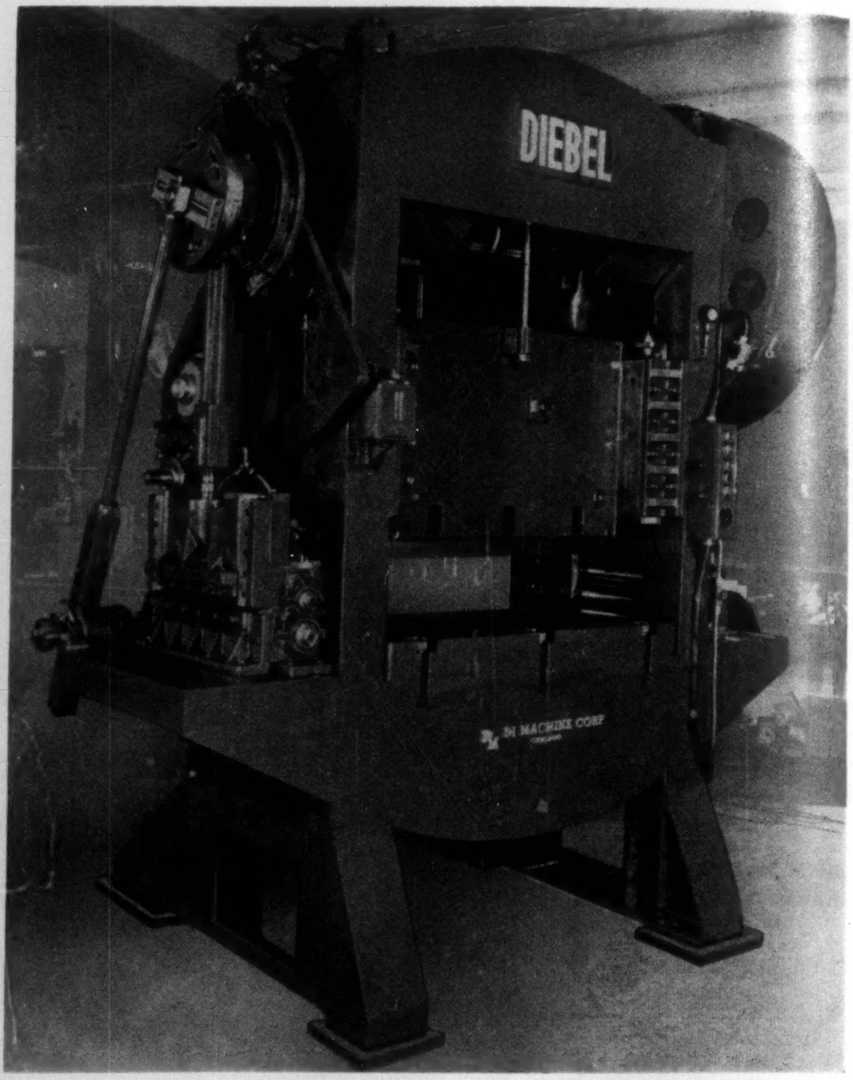
Circle No. 2 on Reply Card



HOPPER FEED

Designed to handle either rolling or sliding parts and to feed them automatically at a predetermined rate to a production machine, unit features low loading height and variable delivery point. Parts are picked up from the hopper by cleats on the moving conveyor and elevated to the delivery point from which they are fed to the production machine. Loading height is 36 inches and hopper capacity is 4 cu ft. Work range is up to 3 inches diameter and 3 inches length on sliding cylindrical parts, and up to 3 inches diameter and 1 inch length on rolling parts. Unit is driven by a ¼-hp, three-phase motor operating through a variable speed drive. **Feedall Inc.,** Willoughby, O.

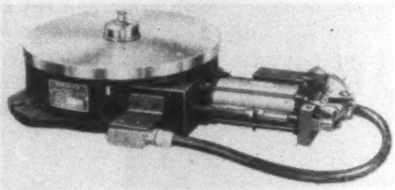
Circle No. 3 on Reply Card



100-TON AUTOMATIC PRESS

Designed for the mass production metalworking field, new 100-ton double crank welded steel press has a speed range from 80 to 240 strokes per minute. The press is built with 40, 50 or 60 inches between uprights and 32 inches front to back. Machine features cylindrical type ram for accurate alignment and air clamped feeds to prevent stock distortion and permit positive feeding. The press is available with single or double feeds and scrapcutter. Standard equipment on the unit includes a balanced crankshaft, air counterbalances, automatic metered lubrication system, completely wired electrical control systems, air clutch and specially designed shock mounts. Press is suited for industries requiring the stacking of parts. Its leg design permits accessible areas under it for installation of stacking devices, and raises the bed height for easier set up. **Di Machine Corp.,** 2701 W. Irving Park Rd., Chicago 18, Ill.

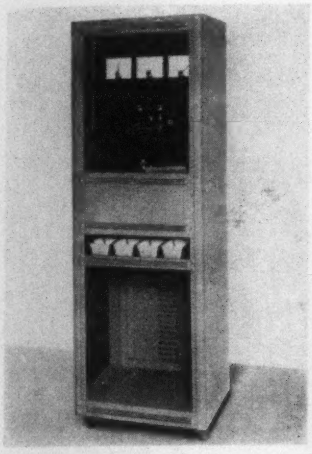
Circle No. 4 on Reply Card



ROTARY INDEX TABLE

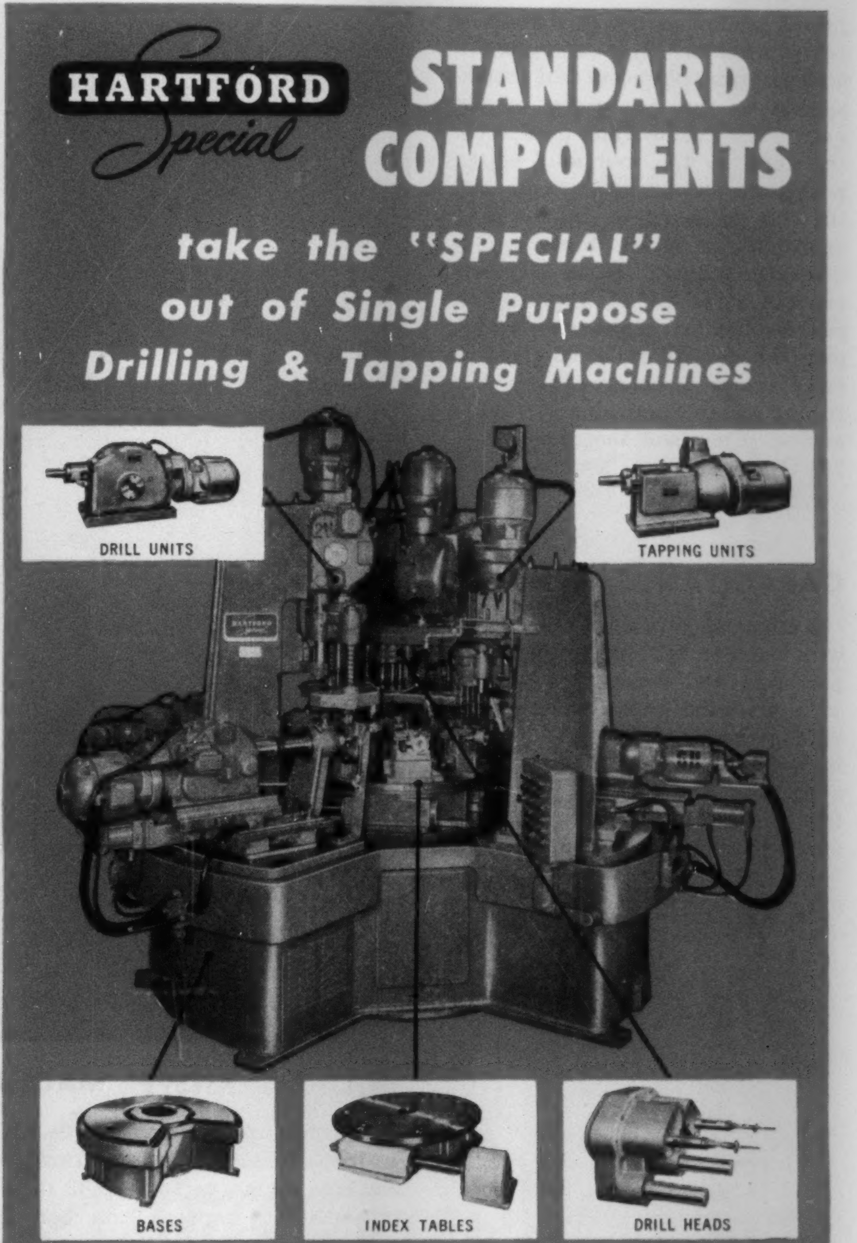
Designed for use where high accuracy in automatic feeding of work to tools is required, 13-inch diameter rotary index table can maintain repeat accuracies as close as 0.0005-inch. Unit features a cam movement which assures a positively locked table top at all times. The table top is equipped with hardened and ground steel dowel pins which are engaged by hardened tool steel pawls to index the top and lock it in exact work position. Table top rotates on hand-scraped surfaces of the base housing. Unit is available in three styles: one for fixed indexing of four stations, one adjustable for indexing either six or 12 stations, and one adjustable for six, nine or 18 stations. **Bellows Co.,** Akron 9, O.

Circle No. 5 on Reply Card



INSPECTION UNIT

Designed for gaging and sorting parts into as many as five specific size categories plus oversize and undersize, inspection unit operates at speeds of more than 3000 parts per hour. Unit will handle parts up to 3 inches in length and ¾-inch OD, and can be arranged for checking length, thickness, OD, or any other external measurement. It can be furnished with any size range designed from 0.0002 to 0.010-inch, and for sorting by increments as small as 0.000050-inch depending on the range. Parts to be measured are fed from a hopper by motor driven fingers and are placed, one at a time, on an anvil beneath a gage head. A voltage produced by the gage head goes through an amplifier to three contact meters, and the meter hands are positioned according to the size of the part being measured. The meter hands make contact with the



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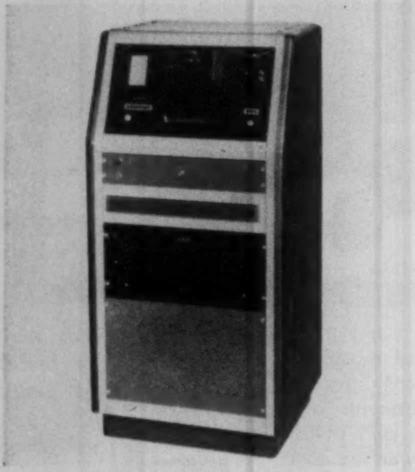
preset contact arms to actuate a relay system. This energizes a sorting gate solenoid that corresponds to the size group of the part. The part is then pushed off the anvil by the feeding-in of the next part, and drops vertically until it is deflected by the solenoid operated gate into a corresponding discharge chute. Basic elements are the same for all applications, but mechanical parts such as the gage head support, anvil, feeding fingers and discharge chutes are furnished to individual requirements. **Cleveland Instrument Co.,** 735 Carnegie Ave., Cleveland 15, O.

Circle No. 6 on Reply Card

CAPACITANCE GAGE

Automatic capacitance indicator with counter readout for both capacitance and dissipation consists of a precision capacitance bridge, with servo drives on both capacitance and dissipation channels for automatic balancing. Operation is from the 117 v, 60 cps line. Instrument will measure capacitance from 100 micromicrofarad to 1.00 microfarad, with dissipation factors up to 6 per cent. When combined with handling equipment, indicator can be used to monitor the production of condensers. It can be modified for digital readout, and to sort condensers into predetermined value groups. It is useful for incoming component inspection and test, and for unattended monitoring of life and environmental tests. **Industrial Control Co.,** Wyandanch, L.I., N. Y.



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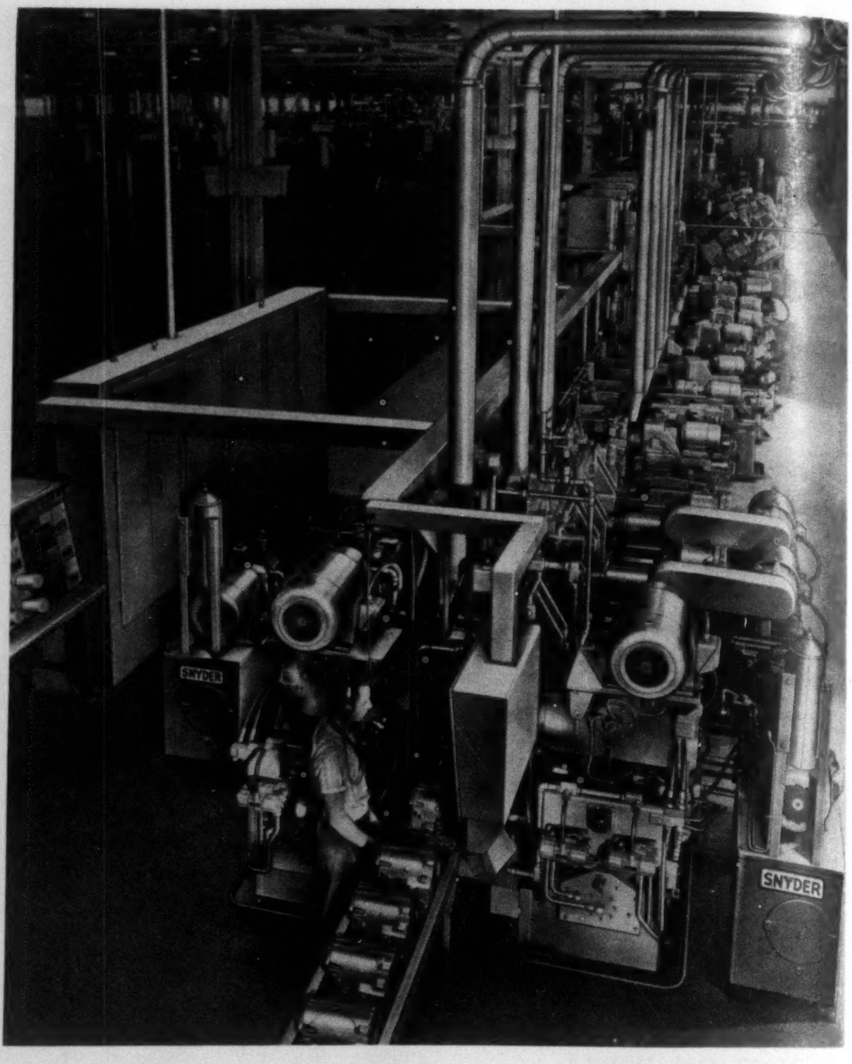
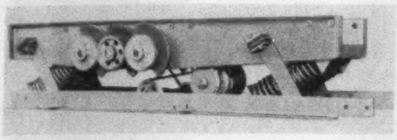


IN-LINE TRANSFER MACHINE

Sectionalized automation is the feature of a new in-line transfer machine which performs 182 milling, drilling, tapping and boring operations on a cast iron automotive automatic transmission case. The 150-ft machine cycles to produce 100 cases per hour at 80 per cent efficiency. Each section of the machine can be individually controlled, loaded and unloaded. Individual transfer mechanisms are provided for each machine section. When one operator controls all sections, the transfer bar controls the operation of each section. Automation devices orient the parts to three different positions for processing through the various machine sections. Duplex boring spindles, in which individual inserted tooth milling cutters are mounted on separate concentric spindles, are featured in two stations on the machine. All boring, facing and milling cutters are inserted-tooth carbide types. Transmission cases which have a milled mounting face and two reamed dowel pin holes are manually loaded on a fixture in the transfer mechanism. The parts are then delivered to the first section which is 40 ft long and has 19 stations and 10 spindles. Here both ends are face milled, a counterbore is turned and faced, three diameters are rough and semifinish bored and faced with duplex cutters, two pads are side milled, a pump pad is face milled and a clearance slot is milled. The part is tipped up 90 degrees at one of the stations, orienting the part with the extension case end up, at which position it remains through the first and second sections. The 47-ft long second section has 31 stations and 91 spindles. Here 51 holes are drilled, countersunk, semifinish and finish reamed, spotfaced and tapped. Then the part is transferred to the third section. This 26-ft long section has 17 stations and 21 spindles. Here a variety of drilling, chamfering, tapping, counterboring, reaming and spotfacing operations are performed on holes in both case sides. At the end of the third section, the part is turned 90 degrees and tipped up 90 degrees, thus reorienting it with the pump face end up. Then it is transferred into the fourth section which is 36 ft long and has 24 stations and 60 spindles. In this final section facing operations are completed and duplex boring spindles are used to finish the production of the transmission cases. **Snyder Tool & Engineering Co.,** 3400 E. Lafayette Ave., Detroit 7, Mich.

Circle No. **8** *on Reply Card*



OSCILLATING CONVEYOR

Vibrating trough oscillated by rotating eccentric weights is designed with a minimum of moving parts. Components of the oscillating conveyor are a drive unit, a trough resting on rocker arms and coil springs, and a supporting base. Three eccentric weights on the drive assembly are held on individual shafts. The shafts are geared together and driven by a counter shaft that is belted to an electric motor. The assembly fits in a section of the conveyor 5 ft long. Oscillating motion of the conveyor is created by centrifugal forces set up by revolving eccentric weights. Three eccentric weights are geared to rotate so that centrifugal forces reach a maximum at two points 180 degrees apart in their circles of travel and alternately impart forward and backward thrusts to the trough. A rocker arm causes material to move upward and forward on the trough. Conveyor will handle ceramics, chemicals, food, rock products, coal, or metal scrap. **Gifford-Wood Co.,** Hudson, N. Y.

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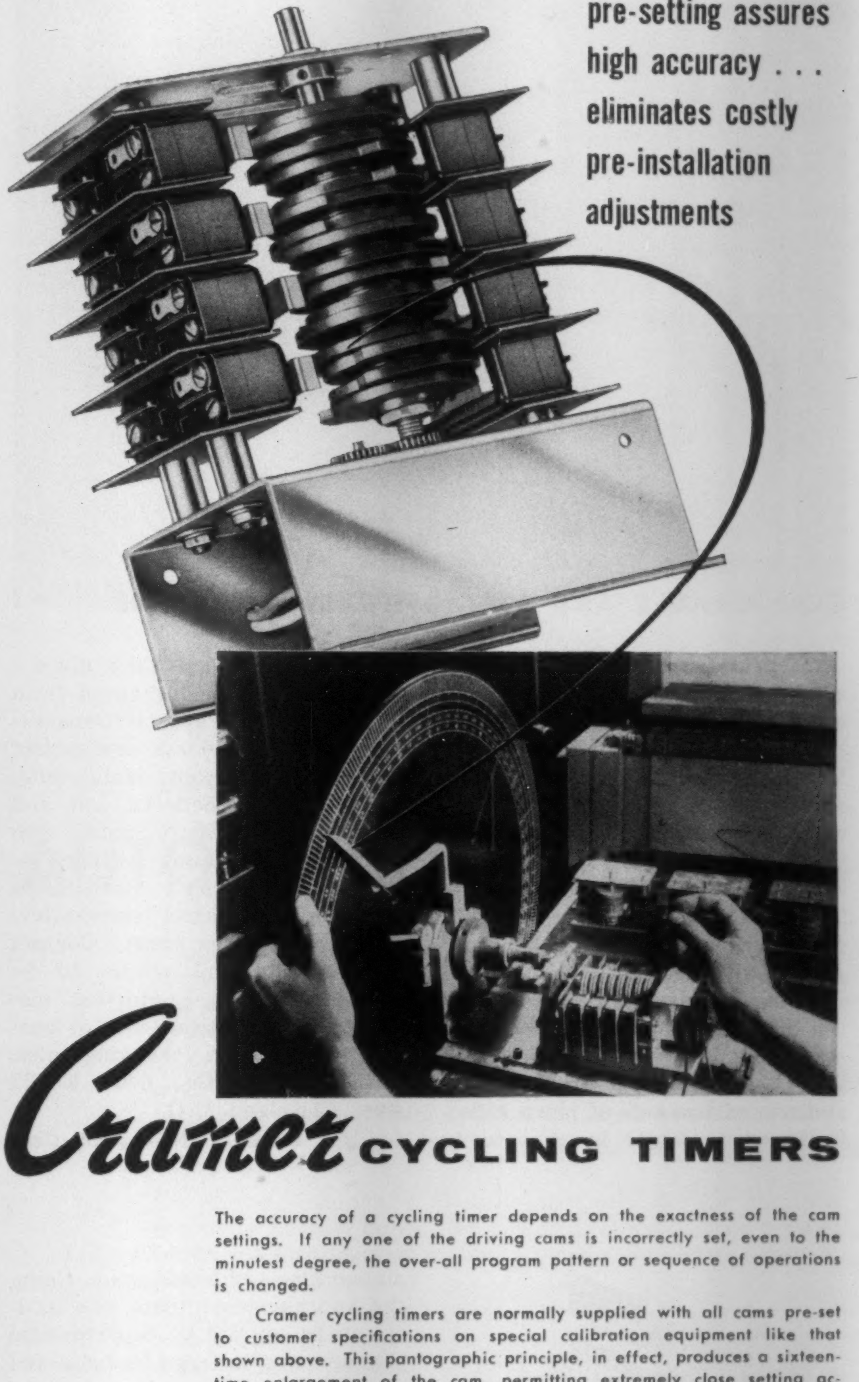


Factory
pre-setting assures
high accuracy . . .
eliminates costly
pre-installation
adjustments

Cramer CYCLING TIMERS

The accuracy of a cycling timer depends on the exactness of the cam settings. If any one of the driving cams is incorrectly set, even to the minutest degree, the over-all program pattern or sequence of operations is changed.

Cramer cycling timers are normally supplied with all cams pre-set to customer specifications on special calibration equipment like that shown above. This pantographic principle, in effect, produces a sixteen-time enlargement of the cam, permitting extremely close setting accuracies.

While these timers can be adjusted in the field, factory setting assures highest accuracy and eliminates costly pre-installation adjustments.

This is but one of the many Cramer customer services designed to provide greater product usefulness and satisfaction at lower cost.

For full information about Cramer Cycling Timers, write for new Bulletin FB-510.

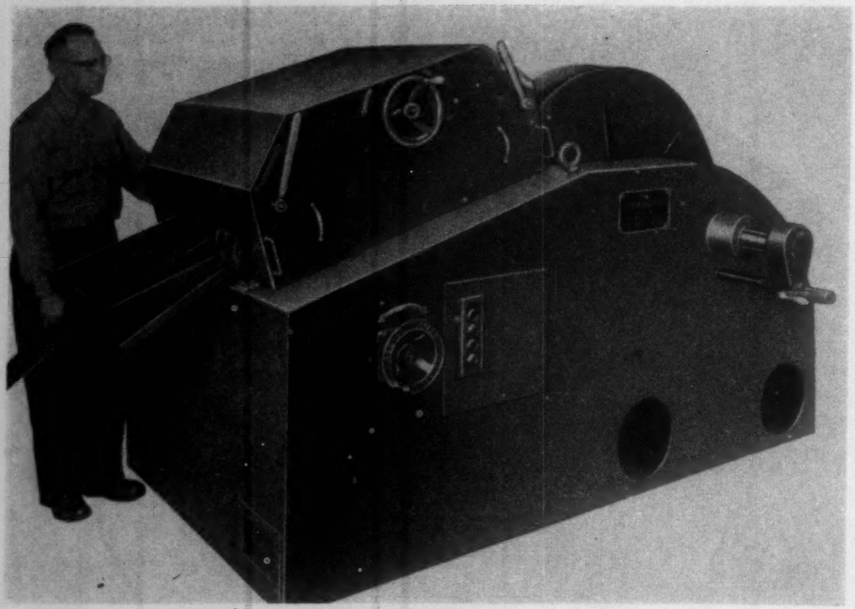
Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 35, CENTERBROOK, CONNECTICUT

13CR55



COIL CRADLE AND STRAIGHTENING MACHINE

Combination coil cradle and straightening machines are designed for use with metal stamping presses and forming machines. Units feature compact construction and ability to carry extra heavy weights. Models are available to handle coil weights from 2000 to 10,000 lb with widths from 8 to 24 inches. Cradle has conveyor type construction with guide plates that rotate with the coil to prevent crimping or damaging the edge of the material. Leveling or straightening unit is available with either five or seven power driven rolls, and one or two sets of pinch rolls. Units are powered by a 4 to 1 variable speed drive which gives a wide range of feeding speed from 30 to 120 fpm. Power is transmitted through a clutch mechanism to the leveling rolls, maintaining proper tension between coil and leveling units. Short control arm with necessary limit switches or electrical contact mechanisms maintain loop control between leveling unit and the press. Contact unit permits coil cradle to be placed closer to production machine without interference of control arms when changing dies. **Brandes Press Co.,** 6408 Euclid Ave., Cleveland 3, O.

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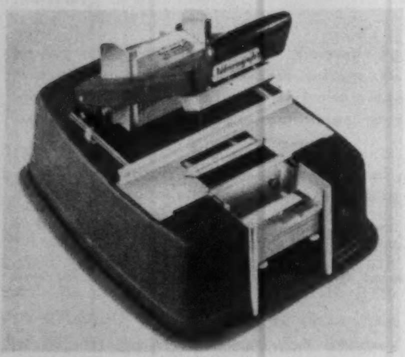


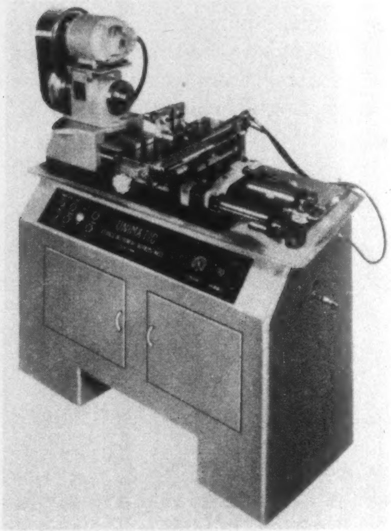
REPETITIVE WRITER

New office machine features a long-life carbon ribbon that produces fine-line printing and keeps plates, files and hands clean. Using the Addressograph plate, new model can be applied to departmental requirements in large business and to the repetitive writing needs of every business. Writer weighs 19 lb and occupies less space than a finger-powered typewriter on desk, table, bench or counter top. Standard equipment includes an automatic plate feed with automatic refile in original order and provision for visual selection of plates to print or not to print at the time a run is being made. **Addressograph Multigraph Corp.,** Cleveland 17, O.

Circle No. **11** *on Reply Card*

BORING MACHINE

Automatic and manual controls, with timers for repetition of predetermined cycles for cutting, dwell and reverse motion of the table and cross slide are the features of precision boring machine. Machine will handle work up to 9-inches diameter, and perform boring operations up to a depth of 6 inches. Headstock has a built-in sine bar to implement accurate boring and turning of tapers. An air-operated spindle brake, and complete, motorized coolant facilities are also features of the machine. Full-round table ways and guide bushings, and a floating support assure correct tool position regardless of contraction and expansion of the machine parts due to changes in weather and temperature. Motor is ½-hp, 1750 rpm, totally enclosed, sleeve bearing type, with spindle speeds available from 775 to 4000 rpm. Total weight of the machine is 1200 lb; required floor space is 28 by 52 inches. Unit was built for machining aircraft parts and for production horizontal jig boring. **Atlantic Instrument Corp.,** 90 Broadway, Norwood, Mass.



Circle No. **12** *on Reply Card*

TAPE TRANSPORT

Designed for use as an auxiliary memory storage device in computers or data reduction systems, a new tape transport is called the Datacord. This magnetic recorder-reproducer can be mounted on a

19-inch relay rack. Unit has a tape speed of 75 inches per second in either direction. Starting and stopping time of the tape is approximately 4 milliseconds. Datacord will accommodate tapes varying in widths from 1/4 to 2 inches. Tape is stored in one basket and during operation is dropped into another basket. In this way, it is necessary to accelerate only the mass of tape which is suspended by the capstan. To accelerate the tape as rapidly as possible, all rotating parts are kept running at full speed at all times. The two tape capstans, each directly coupled to a motor, are undercut. Each capstan has with it a solenoid actuated pinch roll. A biasing force is applied to the solenoid armatures in order to keep the pinch rolls in contact with the capstan at all times. When voltage is applied to either of the solenoids, it is necessary to move the pinch roll only 0.002 to 0.003 inches before the rubber tire on the pinch roll is sufficiently compressed to couple the tape to the capstan. The complete pinch roll assembly can be moved and locked in an outward position to facilitate tape threading. Provisions have been made for lateral and azimuth positioning of the magnetic head. A tape storing reel is provided when the tape is not in use. The loading and storing reel is powered by a 1/200-hp torque motor and can be used for both loading and unloading the baskets. **Brush Electronics Co.,** 3405 Perkins Ave., Cleveland 14, O.

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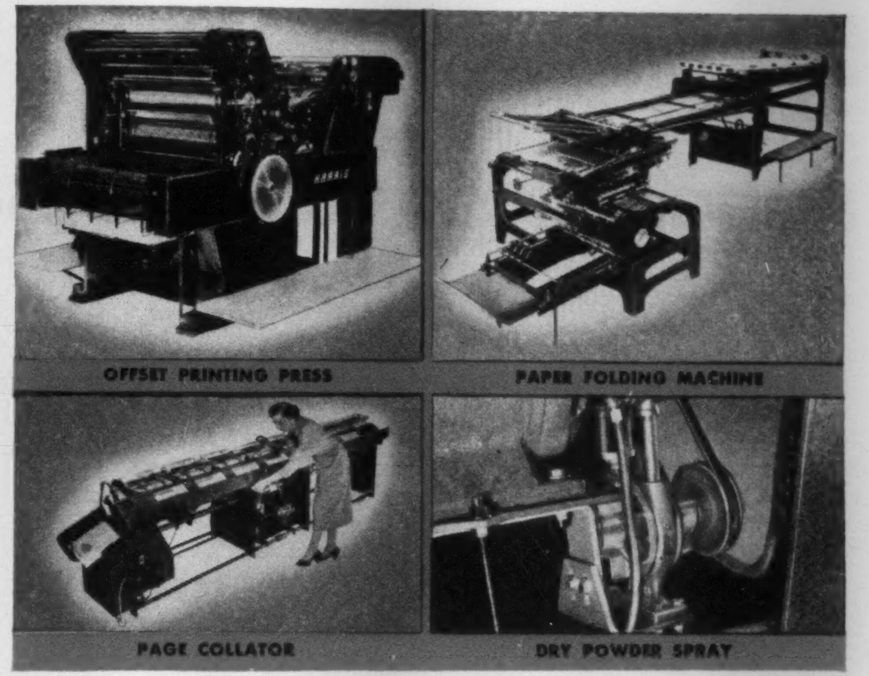


What Gast Rotary Air Pumps do on Printing Equipment may spark valuable ideas for your

AUTOMATIC MACHINES

Automation's an old story to printers! For years, they've enjoyed great labor savings from automatic equipment that feeds and positions stock, "levels" ink, applies it, dries, coats, trims, folds, collates and counts the finished product.

For years too, Gast rotary Air Pumps used on graphic arts' equipment have proved their dependability and uniform high performance—vital characteristics for *any* automatic machine which requires trouble-free components to prevent costly interruptions of interdependent operations.

On printing equipment, Gast Rotaries are used for numerous functions. Suction holds, lifts and feeds stock . . . air pressure blows stock to separate it, blows powder for drying, atomizes liquid for spraying, etc.

With a moderate vacuum of 26", you can lift 13 lbs. per square inch or *1,872 lbs. per square foot of vacuum cup area!* So think over what *important jobs Gast Air Pumps might do* on *your* automatic machines and equipment!

For details on 35 actual applications, *write for "Application Ideas" Booklet.* Gast Manufacturing Corp., P.O. Box 117-E Benton Harbor, Michigan.

USE AIR to hold, lift, position, push, pull, rotate, suck, blow, inflate, evacuate, aerate, atomize, oxidize, etc.

Original Equipment Manufacturers for Over 25 Years

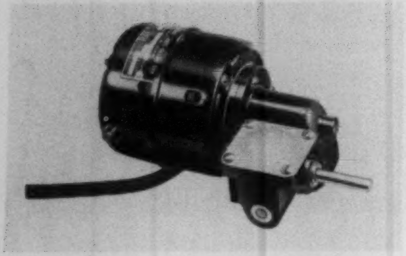
GAST ROTARY

- **AIR MOTORS** TO 3 H.P.
- **COMPRESSORS** TO 30 P.S.I.
- **VACUUM PUMPS** TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems



Gear Reducer

New gear reducer is designed for use with company line of gear motors. Reducer is available in any voltage up to 250, and in speeds as low as 1 rpm. Unit is designed to meet loads to 15 inch-lb. Motor can also be built with an electric governor speed control. It can be rheostat controlled, dynamically or mechanically braked. **Rae Motor Corp.**, P. O. Box 291, Racine, Wis.

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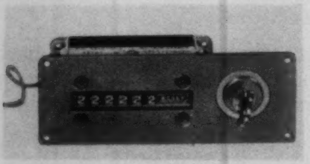

Electric Counter

Tamper proof, tumbler lock reset electric counter is designed for panel mounting. Counter comes equipped with mounting plate, with the lock reset at the right of the plate. Entire assembly can be placed in a panel from the front, and fastened from there. Counter is totally enclosed, affording protection against dust and moisture conditions. Its overall dimensions are 5½ inches long by 2 9/16 inches deep by 2⅛ inches high. Operating speed is up to 1000 counts per minute. Voltage is 110v, 60 cycle, ac. **Durant Mfg. Co.**, 1997 N. Buffum St., Milwaukee 1, Wis.

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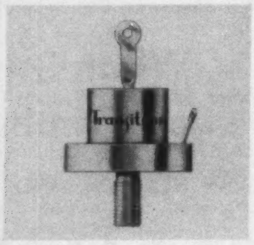

Silicon Rectifiers

Capable of continuous operation at full rated power at an ambient temperature of 125C, new silicon rectifiers also feature reliable operation under wide variations in ambient temperatures. Hermetically sealed construction provides protection against environment. Types range in power handling ability from 10 amp at 50v peak inverse voltage to 5 amp at 200v peak inverse voltage, all rated at 125C. **Transitron Electronic Corp.**, Melrose 76, Mass.

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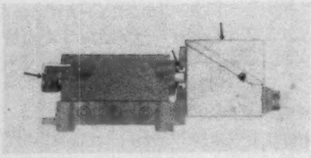

Solenoid Valves

O type solenoid valves feature a sintered bronze filter in the breather hole of the spring cap. Filter, which consists of small bronze particles pressed together into a porous mass, permits air to pass through the filter in either direction, but prevents entrance of dust or grit which under adverse conditions might tend to build up sufficiently to interfere with the proper action of the return spring or work into the internal valve parts. A sleeve, sealed with O rings at two places, prevents dust or other foreign material from entering the area where the solenoid armature contacts the valve plunger, assuring dust free operation at this point. Top half of the two piece cover for the solenoid overlaps and fits tightly over the bottom half of the cover, protecting the solenoid from dust, oil, grit and foreign particles. Top half of the cover can be removed by loosening two screws, providing easy access to the interior of the bottom half of the cover. **C. B. Hunt & Son Inc.**, Salem, O.

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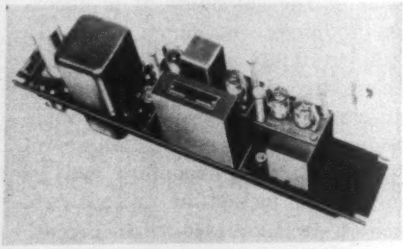

Audio Tone Signaling Units

Used for transmitting and receiving signaling, dialing, telemetering and supervisory controls, audio tone signaling units are available in various combinations of transmitters and receivers. Up to 48 on-off or raise-lower functions can be controlled over a single circuit—telephone line, microwave or VHF radio—by use of the devices, which operate in the range of 425 to 6025 cycles at intervals of 100 or 150 cycles. Units make use of plug-in audio tone generators and highly selective rectifiers. Plug-in units are universal and completely interchangeable. Frequency determining element of the tone generator is a separately mounted small unit, as is the filter for each receiver. **Hammarlund Mfg. Co. Inc.,** 460 W. 34th St., New York 1, N. Y.

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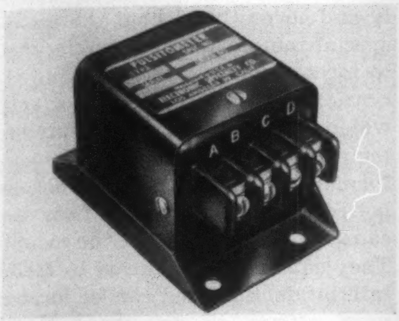

Aircraft Keyer

New keyer called Pulsitometer has been designed to meet the Air Force requirement for a vibration resistant keyer to be used in the overheat warning circuit of all aircraft gas turbine engines, whether jet or turboprop. A keyer such as this is required in aircraft which use a single warning light to indicate two different conditions of overheat, or two pickup points. When one detector is wired through the keyer, the pilot is able to differentiate between sources. It can also be used to key a warning light to indicate any other dangerous conditions. Flashing is done by alternate charging and discharging a tantalytic capacitor through relays. Relays are subminiature snap action types which are resistant to flutter or bounce, and provide clean switching under vibration and shock. Unit will operate over a voltage range of 14 to 30v dc and under all standard Air Force environmental conditions. Use of two output terminals allows unit to be wired either for the warning light to remain on in case of failure, or for it to remain off in that case. Pulsitometer has a flashing rate of 140 cycles per minute at 28v. **Electronic Specialty Co.,** 3456 Glendale Blvd., Los Angeles 39, Calif.

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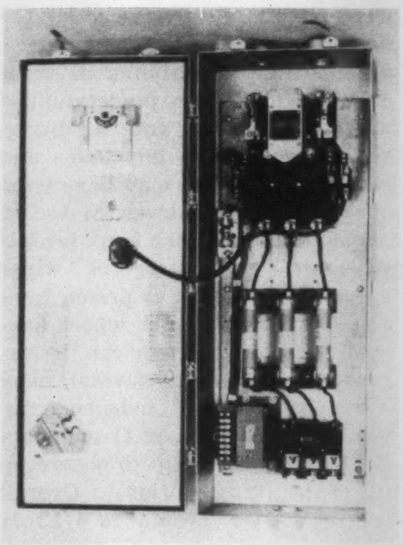

Enclosure for Linestarters

Water tight enclosures for all combination linestarters through NEMA size 2 are fabricated from sheet steel. Pushbuttons are equipped with neoprene caps where it is required to prevent accumulated ice or sleet from interfering with their operation. Neoprene gasket and cover held securely by screws make the enclosure weather proof, water tight, and dust tight. External mounting feet and conveniently located knockouts facilitate installation and service. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa.

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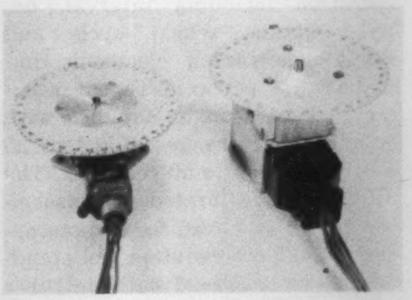

Remote Positioning Device

Called the Torsynator, new remote positioning device consists of a potentiometer as the sender and a low inertia motor as the receiver. Torsynator gives high output torque with low input torque, without requiring use of an amplifier. Unit uses a specially designed dc receiver motor. Accuracy of system is ±0.4 degrees; starting time is 20 milliseconds. Output power is more than 0.1 w. Total weight of sender and receiver, including receptacles, is 19 oz. Other Torsynator systems include 60 and 400 cycle types and a power unit which handles 60 w continuous output, with a receiver follow up speed of 720 degrees per second. **Air Marine Motors Inc.,** 369 Bayview Ave., Amityville, L. I., N. Y.

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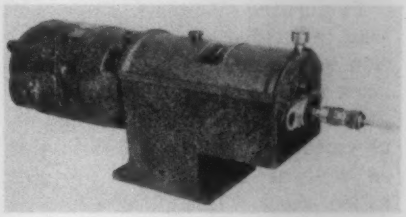

Lead Screw Tapping Unit

Self-contained, electrically operated and controlled lead screw tapping unit is designed for fast precision single and multiple spindle tapping and threading. Using a new principle of instantaneous acting forward and reverse electromagnetic clutches, the unit needs no reversing motor and can be operated at high speeds. A built-in rheostat control which permits the clutch torque to be regulated over a range of from 0 to the equivalent of 2 hp, gives the unit the sensitivity required for the smallest taps yet assures enough power to drive the larger taps. Since the clutches are energized within themselves, there is no end pressure on either lead screw or taps. Unit features a depth control knob to allow tap depth to be set to within ¼-turn anywhere within the maximum stroke of 1⅞ inches. Tapper can be operated in any position or at any angle. It may be used singly or combined with similar units and mounted on a machine base where a special purpose tapping machine is required. **Ettco Tool Co. Inc.,** 594 Johnson Ave., Brooklyn 37, N. Y.

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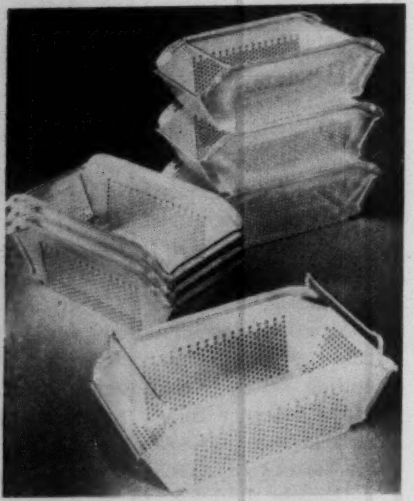
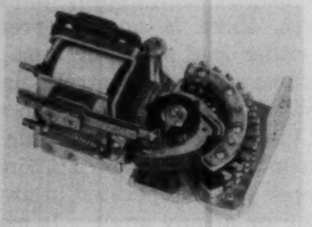


Materials Handling Baskets

Perforated stainless steel baskets of welded, die made construction are available in five different sizes ranging from 12 to 36 inches in length. Units can be supplied in various types of stainless steel as well as in aluminum or cold rolled steel. Design of the basket permits handling parts or products throughout all production operations in the same container, eliminating rehandling of contents into special baskets for dipping or degreasing. When filled, baskets tier in stacks, with contents of each unit visible and accessible through double hopper ends. Empty baskets nest, saving floor space. Baskets can be used with powered belt, overhead, wheel and roller conveyors. Large unit loads can be tiered on skids or pallets for transporting by powered or hand lift trucks. **Chas. Wm. Doepke Mfg. Co. Inc.,** 8806 Blue Ash Rd., Rossmoyne, O.

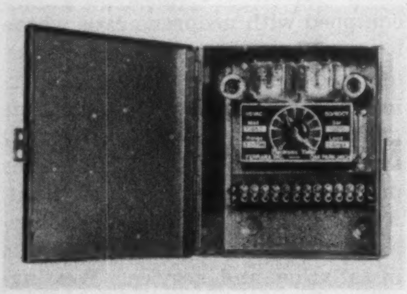
Circle No. 23 on Reply Card



Spring Driven Stepping Switch

New unit in line of rotary switches can function either as a ten-point or an 11-point switch and provide millions of steps without any readjustment. Stepping switch is designed for completing, interrupting or changing the connections in a succession of electric circuits in response to momentary impulses of current. Among its applications are: selecting any desired point in a series, selecting the first unoccupied point in a series, automatically controlling a series of operations in a predetermined manner, counting and totalizing, generating timed impulses, and monitoring. Switch may have from one to eight bank levels of ten or 11 points each. Each bank level is traversed by a pair of wiper springs. The rotor is driven by a stainless steel ratchet wheel having 33 teeth. Wipers can be arranged so that the several bank levels can be used independently to secure ten-point or 11-point operation, or in tandem to secure up to 33-point operation. Overall length of the switch is 4 13/32 inches, including mounting bracket. It is available hermetically sealed. **C. P. Clare & Co.,** 3101 Pratt Blvd., Chicago 45, Ill.

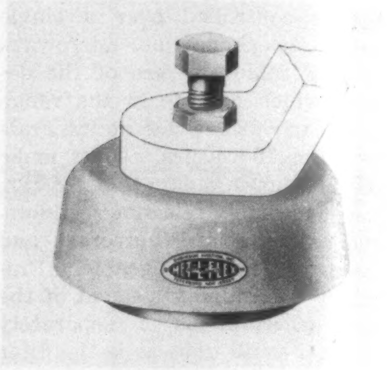
Circle No. 24 on Reply Card



Electronic Timer

Designed for multiple forms of operation including interval, delayed action, repeat cycle and single cycle timing, electronic timer has ±2 per cent repeat accuracy. Timer can be supplied with standard time ranges of 0.3 to 25 seconds, or 0.5 to 50 seconds. The 270 degree calibrated dial assembly can be removed for remote operation. Unit requires no standby power, and cold cathode tubes eliminate warm up time. Timer has 5 amp, isolated load contacts, plug-in relays and open construction. **Ferrara Inc.,** 8106 W. Nine Mile Rd., Oak Park, Mich.

Circle No. 25 on Reply Card



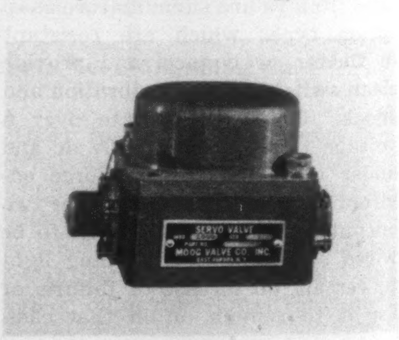
Industrial Machinery Mount

All metal mount features a built-in leveling device which makes it possible to install machinery quickly and correctly without the use of special tools. Mount is engineered to meet standards of shock and vibration control. Exposure to oil, water, solvents, dust or extreme temperatures will not affect its performance. Machines need not be bolted or lagged to the floor because of the stability of the mount. They can be easily moved to facilitate production, and can be located near offices or on upper floors without transmission of vibration or shock. **Robinson Aviation Inc., Industrial Div.,** Teterboro, N. J.

Circle No. 26 on Reply Card

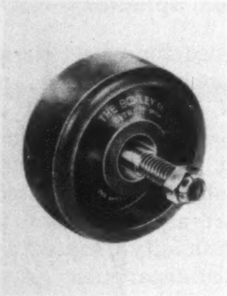
Dry Solenoid Servo Valves

Torque motor is isolated from the hydraulic fluid in proportional type, electrically actuated, hydraulic, four way valves. Units are designed to operate in hydraulic systems of from 1000 to 3000 psi pressure. Units having maximum output flows from 0.1 to 50 gpm for rated control currents between 2 and 40 ma are available. Valves can be used in high performance electrohydraulic positional type servosystems. Applications include servosystems used for guided mis-



sile and aircraft flight controls, radar scanner actuation, contour following machine tools, and automatic packaging equipment. Units contain a first stage push-pull hydraulic amplifier which requires a continuous flow of 0.1 gpm. Oil is internally filtered by sintered bronze elements. Input element of this stage is the polarized solenoid coil of a torque motor that is isolated from the hydraulic fluid. Torque motor armature passes through a tubular, sealed pivot to actuate a flapper between two nozzles, thus creating a pressure differential proportional to the applied signal. Differential hydraulic pressure output applied to the valve spool ends in opposition to two return springs positions the valve spool. This method of valve actuation results in high level spool driving forces, and minimizes spool friction and acceleration forces. **Moog Valve Co. Inc.,** East Aurora, N. Y.

Circle No. 27 on Reply Card



Flexible Conveyor Rolls

Designed to handle formed, painted, embossed or enameled parts without damage or distortion, flexible conveyor rolls are made of specially compounded synthetic rubber. Rolls are oil resistant and feature a Z-type cross section which instantly and continuously conforms to the varying contours of moving loads. Design of the rolls incorporates prelubricated roller bearings engineered to absorb high shock loads. Bearings are centered in dustproof, lintproof retainers and operate on a centerless ground inner race. Conveyor rolls are available completely assembled, with ½-inch socket head cap screws, tube type spacers and self-locking jam nuts. Roll and bearing assembly combine to form

transistor and
digital computer techniques

APPLIED TO THE DESIGN, DEVELOPMENT
AND APPLICATION OF

AUTOMATIC RADAR DATA PROCESSING,
TRANSMISSION AND CORRELATION
IN LARGE GROUND NETWORKS

Engineers
&
Physicists

Digital computers similar to successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

FIELDS INCLUDE

TRANSISTOR CIRCUITS • DIGITAL COMPUTING NETS • MAGNETIC DRUM AND CORE MEMORY • LOGICAL DESIGN • PROGRAMMING • VERY HIGH POWER MODULATORS AND TRANSMITTERS • INPUT AND OUTPUT DEVICES • SPECIAL DISPLAYS • MICROWAVE CIRCUITS

Scientific and
Engineering Staff

HUGHES
RESEARCH
AND DEVELOPMENT
LABORATORIES

Culver City, Los Angeles County, California

a self-contained unit which permits quick replacement on structural conveyor framework, die knockouts and other special equipment. Conveyor rolls are available in soft rubber model for handling intricately shaped parts, light gage metal parts and for applications where impact may damage parts; medium rubber model is used for handling heavier parts. **The Boxley Co.,** 7410 Woodward Ave., Detroit 2, Mich.

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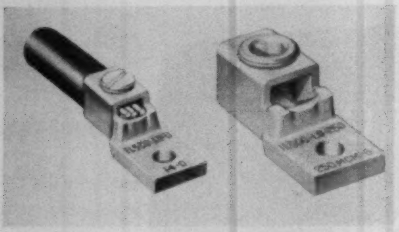

Solderless Lugs

Designed with open barrel, solderless lugs are available in 125, 225, 300 and 400 amp sizes. This construction affords two advantages: greater wire holding space, and visual insertion of the cable. Lugs are produced from hard tempered copper tubing. Because of electrolytic copper used, heat tests show an average of approximately one-half the permitted temperature rise. **Ilsco Corp.,** Mariemont, Cincinnati 27, O.

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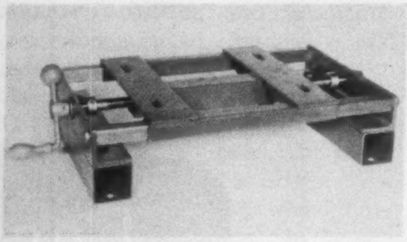
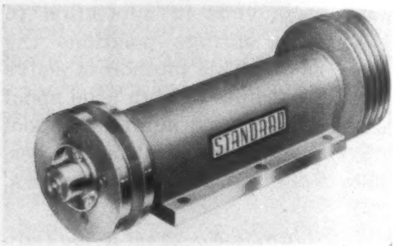


Motor Base

Designed for motors equipped with variable-pitch pulleys, base has finger tip control at the crank handle. Smooth walls of square steel tubes combined with close fitting square steel rails result in a free sliding carriage that can be moved with a minimum of effort regardless of the mounting position of the base. One-piece construction of the carriage prevents the possibility of binding when the motor is bolted to the base. The carriage has enough travel to cope with the requirements of any variable-pitch pulley, even where the drive is at a considerable angle from the plane of the base. Low construction makes installation possible where height clearance could be a problem. Risers are used only where existing mounting facilities do not provide clearance for the crank handle. **Automatic Motor Base Co.,** Windsor, N. J.

Circle No. **30** *on Reply Card*



Precision Spindles

Designed for wheel sizes from 8 to 60 inches diameter, precision spindles are powered by a motor from ½ to 50 hp. A 3-inch taper per foot spindle nose on each end is available with illustrated model. Units are assembled and tested in a dust-humidity-temperature-sound controlled department. Accessories such as driving pulley or sheave with wheel holder and balancing arbor are dynamically balanced. Illustrated model has a flanged base design for mounting; spindle with same dimensions is available in block base design as well as cartridge or flanged design. **Standard Electrical Tool Co.,** 2550 River Rd., Cincinnati 4, O.

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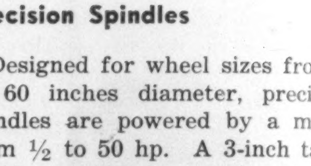

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FEATURES:

- Unique, staggered double brush pick-off system.
- Reads out serially into relays or single or multiple scan matrices.
- Analog-digital or digital-analog operation.
- May be time-shared.
- Syncro-mounted.
- Associated circuitry can be designed to fit your data-handling problems.

CODE	MODEL*	RESOLUTION PER INPUT SHAFT REV.	RESOLUTION OVER FULL RANGE	DIMENSIONS DIAMETER X LENGTH
BINARY	7 digit	128	1 part in 128	2" x 2 49/64"
	13 digit	128	1 part in 8192	2" x 3 19/32"
	17 digit	128	1 part in 131,072	2" x 4 13/16"
	19 digit	128	1 part in 524,288	2" x 4 13/16"
BINARY CODED DECIMAL	0-2000	200	1 part in 2000	3 1/16" x 4 27/32"
	0-3600	200	1 part in 3600	3 1/16" x 4 27/32"
	0-20,000	200	1 part in 20,000	3 1/16" x 4 27/32"
	0-36,000	200	1 part in 36,000	3 1/16" x 6 3/8"
GRAY	8	256	1 part in 256	3 1/16" x 1 11/16"
*SPECIAL UNITS AVAILABLE	**Precision gearing** **Shaft Speed:** 120 rpm continuous **Operating temp:** —55° C to +75° C **Shock and Vibration:** up to 15 G, 5 to 500 cps.		**Life Expectancy:** Function of lead current. For 13 digit unit @ 2 ma. per brush, life approx. 5x10^8 breaks or makes at approx. 120 rpm.	

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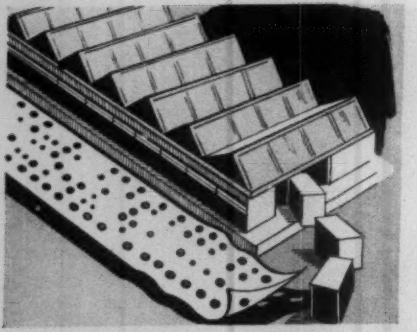

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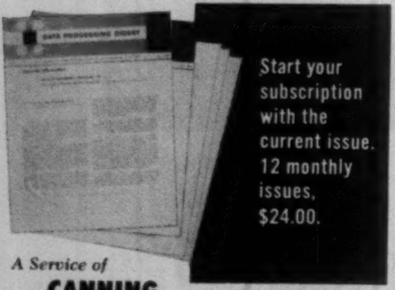
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psi. Cup seals used on piston and rod assure positive sealing at low air pressures. Heavy web sections are used to provide strength required for sealing pressures. Single cartridge contains both piston rod seal and rod wiper. Internal damage and excess noise at high speeds are prevented by newly designed cushions. Cylinders are available in bore sizes from ½ to 8 inches, in seven different mounting styles including flange, swivel, base and tie rod mounts. Various stroke lengths are available. Cylinders can be furnished with different accessories and modifications to meet special requirements. **Automation Products Div., Bill-Dee Corp.,** 405 Crystal Lake Rd., McHenry, Ill.

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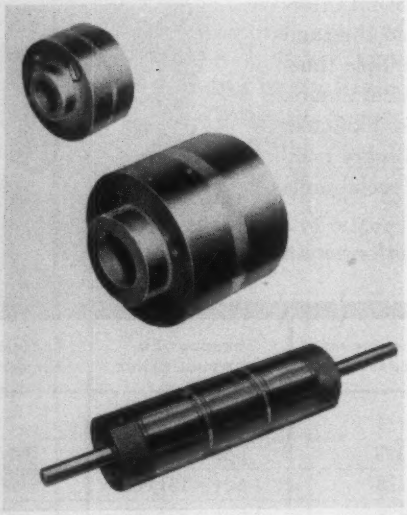

Magnetic Rolls

Designed to meet problems of automation in the metalworking industry, group of small diameter permanent magnetic rolls are made up of two basic types of rolls, in four different diameters. Some features of magnetic rolls are: faster pickup and more positive control of sheets, tubes and pipes on conveyor lines; reduction of the conveyor line lengths because of the strong controlling action of the magnetic rolls; assurance of more constant speed because slippage is eliminated; better control thereby eliminating cobbles and downtime. Rolls are designed for use in automatic handling and conveying of sheets during baking, painting, annealing, stamping and trimming operations. First type, designed for sheet feeding and conveying, is built in 4 and 5-inch roll diameters. Four-inch roll has a 1¼-inch shaft and is available in widths from 4 to 24 inches in 2-inch increments; the 5-inch roll has a 2½-inch diameter shaft and can be supplied in widths from 4 to 72 inches, in 2-inch increments. Second type has been developed to afford spot control in particular conveying problems. Units are available in two sizes: 2½-inch diameter by 1 3/16-inch wide, for use on a ¾-inch diameter shaft; and 4⅜-inch diameter by 3½-inch wide, for use on a 1½-inch diameter shaft. Magnetic rolls are self-powered and involve no electricity, wires, fuses. **Eriez Mfg. Co.,** 1945 Grove Dr., Erie, Pa.

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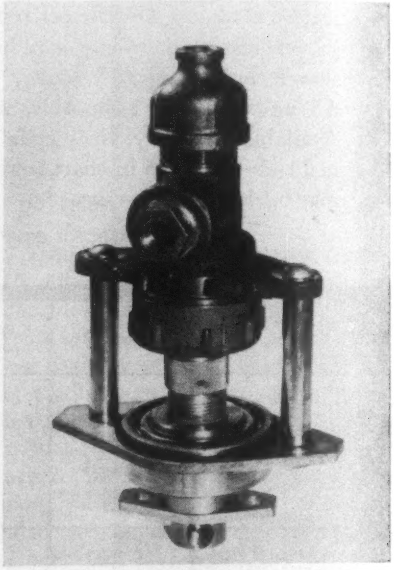
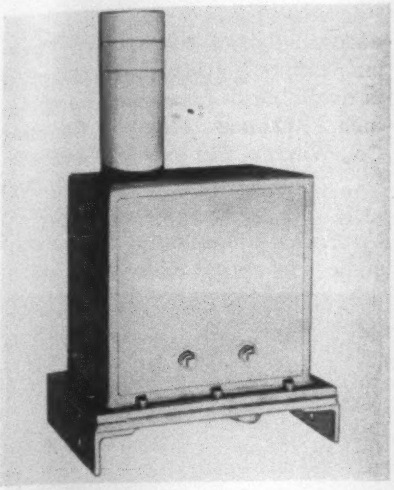


Rotating Joint

Double passage rotating joint is available in a packaged unit which can be installed in applications handling either air or hydraulic pressures where it is necessary to rotate two or more members inside each other. Construction of the joint prevents any thread strains in case of run-out of any of the individual rotating members. Joints are available with single, double or triple rotating passages, and can be used on bottle filling machinery, packaging machinery and all types of machine tools where it is necessary to control air or hydraulic cylinders during rotating or oscillating movements. Joints require no packing. They are manufactured with connections ¼-inch and larger. **Rotherm Engineering Co. Inc.,** 7280 W. Devon Ave., Chicago 31, Ill.

Circle No. **34** *on Reply Card*



Electronic Relay

Called Infra-Ray relay, electronic device can be used to actuate at a safe distance any device associated with high temperature operations. Relay will turn on cooling sprays, actuate hot strip coilers, operate hot rolled rod receiving equipment, stop pouring of molten metal at the correct level, activate recorders of high temperature instruments, sound safety signals when hot material is in motion, and stop hot material at the right location on cooling beds. Unit is self-contained, providing relay action brought out to three terminals: common, normally closed and normally open. Maximum contact ratings are: not more than 250 va, rms, at any time; not more than 5 amp immediately prior to opening; not more than 500 v immediately prior to closing. Power requirements are 115v ±10 per cent, 60 cycle, 0.1 amp, with one side grounded. **Industrial Gauges Corp.,** Englewood, N. J.

Circle No. **35** *on Reply Card*

Insulated Fittings for Raceway

New connection concept using built in insulation provides safety feature for raceways. Built in plastic bushings are used to prevent wiring from coming in contact with the metal of the raceway at the outlet. Bushings are colored bright blue for easy indentification. New fittings are designed for rigid, electrical metallic tubing, and flexible raceways. They protect wire insulation from damage and reduce, up to 50 per cent, the effort required to pull wiring through a raceway, according to tests. Also under development are self-insulated threadless connectors for rigid conduit and liquid tight raceway connectors. Among features of plastic bushings are surface smoothness, providing low friction for wire pulling and prevention of skinning and abrasion of wire insulation. Bushings also resist corrosion and have high impact strength. **Thomas & Betts Co.,** 2838 Butler, Elizabeth, N. J.

Circle No. **36** *on Reply Card*

ELECTRONIC TECHNICIANS AVAILABLE

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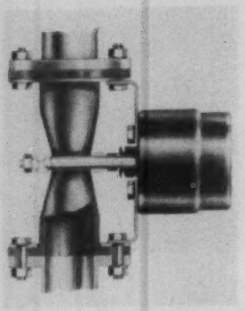
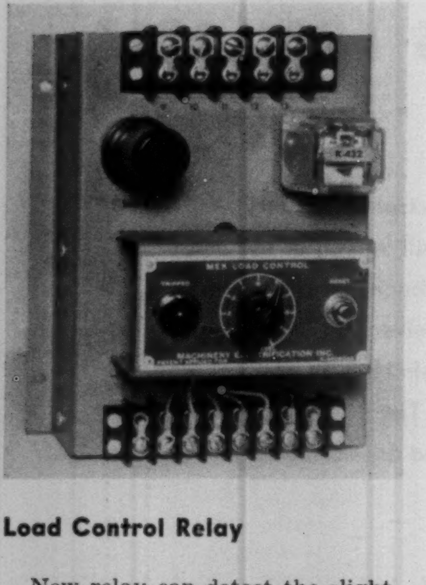


Pinch Type Valves

New flanged valves are designed to handle corrosive materials or abrasive slurries, wet or dry. Valve is of the straight through flow, pinch type, consisting of a flanged rubber body and self-supported air operated pinching mechanism. High and low pressure valves give bubble tight shut-off and are available either with a positioner for flow control, or without a positioner for on-off service. Rolling diaphragm type air motor operator is rated for 125 psi. Valve sizes are from ¼ through 14 inches for a maximum of 100 psi line pressure and a maximum of 180F operating temperature. **R. K. L. Valve & Mfg. Co.,** Dept. 6, 1623 Elaine St., Philadelphia 19, Pa.

Circle No. 37 on Reply Card



Load Control Relay

New relay can detect the slightest change in input current to the machine or process drive motor, and can be used to correct the difficulty, stop the machine or process, adjust the feed or sound an alarm. Relays can be used to protect tapering rolling mills, punch presses and milling machines from damaging overloads. They can also be used to indicate the end of spark out periods, to control feeds, to indicate wheel glazing on grinding wheels and to control injection molding presses. **Machinery Electrification Inc.,** Northboro, Mass.

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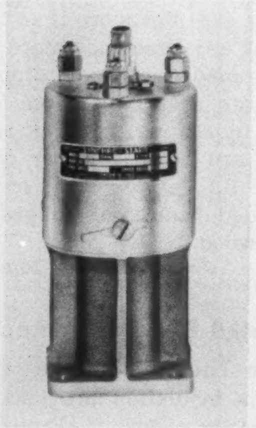

Speed Sensitive Switch

New governor can be arranged to open or close three separate circuits at three different speeds between 1200 and 10,000 rpm. Operating mechanism consists of rotating governor flyweights acting upon snap switches. This combination eliminates the need for collector rings. Contacts are rated 10 amp at 115v ac. Standard units are splash proof and all parts are either plated or made from noncorrosive metals. Special waterproof and/or fungus proof units are available. Switches can be used to operate electrical circuits at various speeds on most types of rotating equipment. **Synchro-Start Products Inc.,** Skokie, Ill.

Circle No. 39 on Reply Card

Miniature Coupling

Designed for use in the field of timing machinery and electronically controlled automatic machines, flexible coupling weighs approximately ½-oz. Coupling is of nonmagnetic (aluminum - beryllium) construction and has minimum backlash. Crosspull and end thrust on connected shafts are almost eliminated by the flexibility of the coupling. Unit is well adapted for Selsyn or other drives where backlash cannot be tolerated. Coupling is available in bore sizes up to ¼-inch. **Thomas Flexible Coupling Co.,** Warren, Pa.

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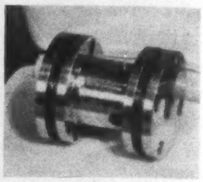

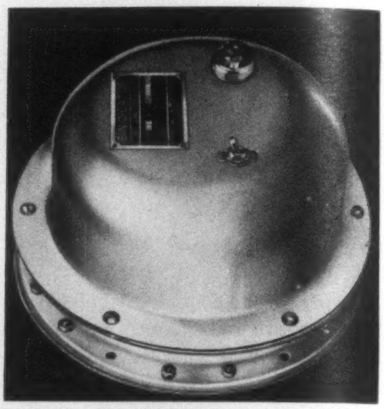

Bin Level Indicator

Diaphragm operated switch is designed for operation on all bulk materials which will flow through a bin. New model Bin-Dicator has a built in signal light for use in installations requiring a light which can be readily seen by an operator. A toggle switch is provided so that the signal light may be turned off if desired. In operation, a flexible diaphragm is exposed to the material in the bin. As the material builds up to the Bin-Dicator, pressure of the material forces the diaphragm against the counterweighted lever mechanism. As the lever mechanism is tipped in response to this pressure, a limit switch located in the Bin-Dicator housing is actuated and automatically turns on the signal lights. Diaphragm materials include cloth, rubber, neoprene with cloth interlining, fiberglas and asbestos cloth of several thicknesses. Units are suitable for use on packaging hoppers, scale hoppers and small bins handling nearly any bulk material. **The Bin-Dicator Co.,** 13946 Kercheval Ave., Detroit 15, Mich.

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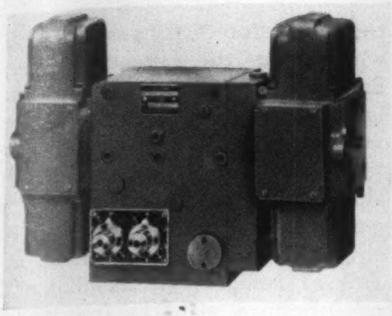


Control Panels

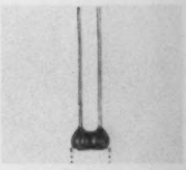
Rapid traverse forward, either one or two adjustable forward feed rates and rapid return are among the features of new traverse and feed control panels. Units are available either all electrically operated or with electrically operated reversing control and cam operated feed selector. Electrical portion of panels is solenoid controlled and pilot operated. Control panels are so designed that if a solenoid burns out, rapid traverse forward or rapid return will not occur out of cycle and endanger tooling. Gasketed covers seal solenoids from moisture and dirt. A built-in terminal box provides easy access to solenoid connections. Feed rates are adjustable over the full range. All panels are designed for subplate mounting and can be furnished with or without subplates. **Double A Products Co.,** Manchester, Mich.

Circle No. **42** *on Reply Card*

Electrical Impulse Counter

Automatic cycling predetermining counter is presettable in seconds for any number up to 100,000. On reaching predetermination, double pole, double throw process control switch is thrown. Counter resets automatically by motor and is ready for the next cycle. Unit is also resettable by signal or manually by a lever. Counter may be reset during the cycle without changing setting. It gives a visible progress count. An eight digit totalizer is optional. Counter is available for panel mounting and for stroke, revolution or measuring counting. **Presin Co.,** 802 N. Fairfax Ave., Los Angeles 46, Calif.

Circle No. **43** *on Reply Card*



Miniature Mica Capacitor

New dipped mica capacitor has parallel leads which provide versatility and safe use of the unit in such applications as printed circuits. Rated at from 1 to 510 mmf at 300v dc and up to 400 mmf

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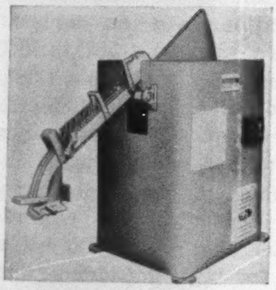
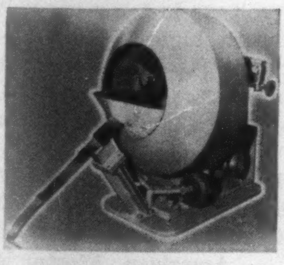


Models 1500 and 2000



Model 400

HOPPER-VIBRATORY-ROTARY-BLADE FEEDS

These fully automatic, self-driven units are designed to serve as auxiliary equipment for many types of production machines, such as centerless grinders, drilling machines, pipe and tube threaders and similar units, handling such small parts as bolts, screws, valves, piston pins, etc.

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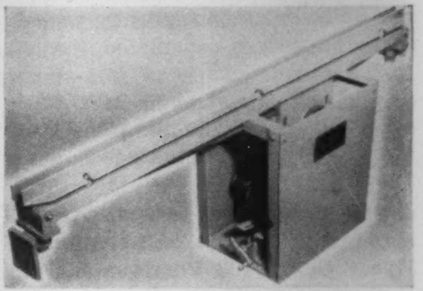

Transfer Conveyor

ELEVATING AND TRANSFER CONVEYORS

These units are a necessary part of the equipment used to convey parts automatically from one production operation to another.

Send samples, prints or production data for production estimates and related information.

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at 500v dc w, capacitor provides minimum capacity tolerance of ±½-per cent with stability over a wide temperature range. Measuring 7/16-inch long by 9/32-inch wide by 5/32 to 3/16-inch thick, unit has a phenolic casing which provides assurance of long life and performance in a variety of transistor circuits and other miniature electronic equipment in military and civilian applications. **Electro Motive Mfg. Co.,** Willimantic, Conn.

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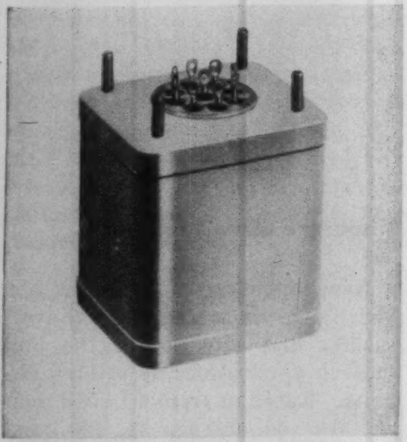

Magnetic Amplifiers

New series of magnetic amplifiers are available over wide ranges of impedance, power gain, response time and supply frequency. Toroidally wound reactors are used throughout the amplifiers. Units are available in hermetically sealed cases or plastic capsulated forms. Illustrated model is a two-stage amplifier. Power gain is 2,000,000; input impedance 200 ohm. The load impedance is 3000 ohm and supply frequency 400 cps at 115v. Response time is one second. Necessary rectifiers are self-contained. **Hycor Co.,** 11423 Vanowen St., N. Hollywood, Calif.

Circle No. **45** *on Reply Card*

Edgewound Brazing Washers

Produced without die charges or tooling costs, edgewound washers reduce silver brazing costs and eliminate scrap waste. Flat wire alloy is wound on edge and then cut partially through. The coil of washers is then shipped intact. When used, each washer is snapped from the coil and preplaced on work as needed. Unused washers remain in coil form. This method of winding flat wire from standard wire stocks eliminates lead time for dies and lead time for exact strip required for blanked washers. Units can be used with induction, gas-air furnace or any of the commonly used heating methods. They are available in diameters up to 4-inch ID, and are held to close tolerances in thicknesses from 0.010 up. **Lucas-Milhaupt Engineering Co.,** Cudahy, Wis.

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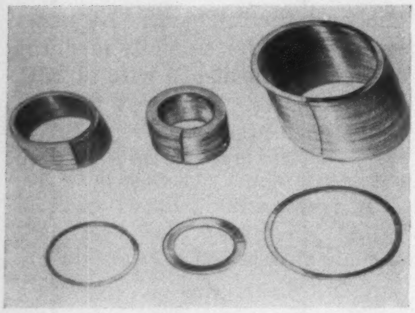

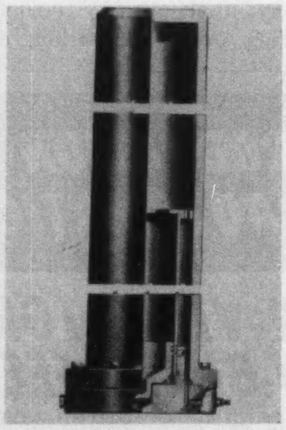

Separator Type Accumulator

Large capacity separator type accumulator is designed to maintain constant pressure, eliminate shock and surges, and compensate for fluid leakage in hydraulic systems. Double shell unit has a floating piston which transmits the pressure of the precharged gas to the working medium and prevents entraining gas in the hydraulic fluid. Gas is introduced under pressure into the outer shell of the accumulator. Then the gas is permitted to enter the upper end of the inner cylinder. There it exerts its pressure against the floating aluminum piston. The constant pressure of the gas against the piston forces it against the oil which enters the pressure balanced inner shell from the main hydraulic line. Pressure of the working medium in the outlet line is thereby maintained at constant pressure. Outer shell acts both as a gas container and as a protective cover to insure that damage inflicted through rough handling will not interfere with the free movement of the piston. Accumulators are designed for 2000 psi and will deliver 2310 cu in. of oil with a pressure drop of 10 per cent, and hold a net gas capacity of 21,950 cu in. **Superior Hydraulics Div.,** 15201 St. Clair Ave., Cleveland 10, O.

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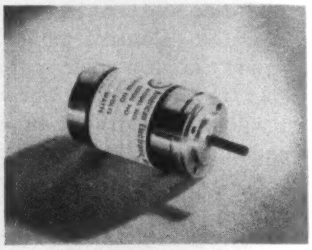

Impedance Resolver

Designed for precision reduction systems, industrial process control, radar positioning, guided missile control, fire control systems, automatic plotters and computer systems, new impedance resolvers feature operation over an ambient temperature range of −55C to 85C. Unit weighs 4.7 oz and has a 1.065-inch outside diameter by 1.85-inch long BuOrd type case. Resolver is available with various shafts, including spline, pinion or plain termination, according to requirements. Input voltage at 400 cps is 0 to 100v for high impedance, and 0 to 60v for low impedance. Maximum null voltage is 1 mv per volt input for both high and low impedance. Null spacing for high and low impedance is ±3 minutes. Input impedance is 3500 ohms measured at 78 degrees ±10 per cent for high impedance; for low impedance input impedance is 800 ohms measured at 76 degrees ±10 per cent. **American Electronic Mfg. Inc., Instrument Div., American Electronics Inc.,** 9503 W. Jefferson Blvd., Culver City, Calif.

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new CATALOGS AND LITERATURE

Metal Working Machinery

Kane & Roach Inc.—Standard and custom built metalworking machines designed and built by company are illustrated in 58-page brochure. Photographs of machines and applications include straighteners, forming machines, benders, slitters and edgers.

Circle No. 49 on Reply Card

Reciprocating Boosters

Miller Fluid Power Co.—Double-acting reciprocating boosters are illustrated and described in a four-page bulletin. Basic circuit, two rapid pressure build-up circuits, two slow pressure build-up circuits and mounting and dimensional data covering these boosters in 4, 5, 6, 8, 10, 12 and 14-inch bores in 1 through 5½-inch diameter rams are included.

Circle No. 50 on Reply Card

Electromagnetic Relays

Potter & Brumfield Mfg. Co. Inc.—Comprehensive 70-page brochure contains 23 technical papers dealing with aspects of relays. Papers were authored by relay engineers, and were originally presented at the Third National Symposium on Electromagnetic Relays. Numerous graphs and photographs are used to illustrate the papers.

Circle No. 51 on Reply Card

Lubrication Systems

Farval Corp.—Twenty-page bulletin discusses centralized lubrication systems using dual supply lines. Lubricant measuring valves and their operation are illustrated. Automatic pumps, spray valves, fittings and accessories are described and illustrated. Application photographs illustrate systems being used in various industries.

Circle No. 52 on Reply Card

Motor Catalog

Peerless Electric Co.—Eight-page catalog describes line of ½ to 30 hp, single-phase, polyphase and dc motors. Information on selection of the proper motor, standards and specifications, special mountings and modifications, frame sizes, and a listing of sales and service offices are included in the brochure.

Circle No. 53 on Reply Card

Nuclear Radiation

Radioactive Products Inc.—"Improved Manufacturing and Processing Through Nuclear Radiation" is the title of a new four-page bulletin. Use of radioisotope type thickness gages for improving quality and reducing rejects; Gamma ray radiographic inspection of forgings, castings, and machined parts to detect internal flaws and structural weaknesses; and use of nuclear radiation in the food, drug and chemical industries for product testing and process control illustrate applications of consulting services such as offerred by this firm.

Circle No. 54 on Reply Card

Hydraulic Transmission

Gerotor May Corp.—Four-page brochure discusses variable speed hydraulic transmission which consists of a driven oil pump and an output oil motor. Transmission is designed for use on agitators, beaters, can and bottle making machinery, conveyors, dairy machinery, printing presses and other equipment. It features instantly variable speeds without stopping, automatic braking, positive speed sensitivity and reverse rotation. Brochure includes photograph, performance chart, technical data and dimensions of the unit.

Circle No. 55 on Reply Card

Instrument Charts

Bristol Co.—Fourteen-page bulletin outlines need for good charts, and methods and controls used in the manufacture of charts for recording and controlling instruments as well as for special instruments. Sample of paper used for charts is inserted, along with discussion of inks and pens.

Circle No. 56 on Reply Card

Model Layout Catalog

"Visual" Plant Layouts Inc.—Information on line of 3-dimensional layout equipment is given in combination price list and catalog. Fifty-page catalog lists over 5000 scale models, including equipment such as machine tools, workbenches, shop trucks, welders, bins, shelving, conveyors, heat treat, dip tank and paint spray equipment, office equipment and warehouse equipment. Items are listed alphabetically by the manufacturer. Fourteen-page price list is divided into three sections: the average cost of various types of complete layouts, the prices of buildings and individual pieces of the various models and planning equipment on a per piece basis, and prices of incidental layout supplies.

Circle No. 57 on Reply Card

Automatic Welding Cost Analysis

Pandjiris Weldment Co.—Eight-page bulletin is a production cost comparison of automatic and manual electric arc welding of seams for cylindrical and elliptical vessels or pipe. Eighteen cost factors affecting the cost of welding footage are presented in columnar form to give unit cost. Accompanying graph depicts unit production and cost per day. Photographs of mandrel seamers, welding head manipulator, and tilting turntables are also included.

Circle No. 58 on Reply Card

Oil Hydraulic Cylinders and Valves

Pathon Mfg. Co.—Cylinders and valves are covered in 32-page brochure which also details standard dimensions for connecting eyes, mounting brackets, oversize rods, rod wipers, and wrench flats. Discussion of cylinders covers length of stroke, cushions, speed controls, cylinder bodies and heads, piston assemblies, bleeders and rod packings. Eight 2000 psi types are illustrated, and their specifications given. Also covered are eight 1000 psi types. Photographs and charts are used to illustrate material in the brochure. Charts are included to aid in cylinder selection.

Circle No. 59 on Reply Card

Gravity and Power Units

Standard Conveyor Co. — Conveyors and drives are discussed in 28-page illustrated bulletin. Among types of conveyors covered are roller, wheel, and belt models. Photographs, specifications, and diagrams illustrating operation of units are included. Conveyors covered include portable piling and utility units as well as fixed installations.

Circle No. 60 on Reply Card

Tool Control Units

Royal Design & Mfg. Inc.—Metal cabinet type tool control units are the subject of a four-page brochure. Units feature cyclemeter which indicates the stage of tool life and can automatically stop machine when tools need to be changed. Standard and special gages for all tool lengths are attached on the face of the tool control board. Photographs of tool control unit are included in the brochure.

Circle No. 61 on Reply Card

Swivel Joints for Piping

Barco Mfg. Co.—Swivel joints designed to provide flexibility in piping are the subject of a 12-page brochure. Joints are used for forming dog leg connections to moving or movable machine parts, such as the steam heated platens on plastic or rubber molding presses. They are also used for pivot point pipe connections where a piping line is connected through a hinge pin or hub. Bulletin contains specifications, dimensions and application data on line of joints.

Circle No. 62 on Reply Card

Compression Plugs

Hermetic Seal Products Co.—Complete technical data and drawings on variety of polarized plugs are given in 12-page catalog. Octal, loctal, miniature and rectangular types of all-glass and all-metal construction are illustrated. Octal types are available with tubular, straight-cut or flattened and pierced solid terminals. Miniature types are standard with rounded, hooked or flattened and pierced solid terminals. Rectangular types are standard with flattened and pierced terminals. Dimensions and design data are included.

Circle No. 63 on Reply Card

Hydraulic and Pneumatic Components

Aircraft Products Co.—Precision hydraulic and pneumatic components are described in 34-page bulletin. Line of selector valves, restrictor valves, sequence valves, check valves and shut-off valves are illustrated. Line drawings, tables and flow charts give construction and operating specifications. Components designed for aircraft and general industrial use, such as hydraulic and pneumatic actuators, spring and air-loaded accumulators, lock valves, solenoid operated fuel shut-off valves, synchronized shuttle valves, flap synchronizing valves, master brake control units, hydraulic canopy actuators and hydraulic aircraft steering controls also are shown.

Circle No. 64 on Reply Card

Automation in Heat Treating

Ferguson Equipment Corp.—Illustrations of heat treating furnaces, automatic control panels, atmosphere safety devices, atmosphere generators, and washing machines are contained in a four-page folder. Seventeen types of industrial heat treating equipment are shown, along with a photograph of the Unitline, a completely self-contained, automatic, continuous heat treating unit.

Circle No. 65 on Reply Card

Automatic Packaging Equipment

Pak-Rapid Inc.—Four-page folder illustrates and describes line of automatic packaging equipment. Six interchangeable feeding mechanisms including a semiautomatic magazine feed for identical circular shapes; a semiautomatic tray conveyor feed for an assortment of

Panel Meters and Pyrometers

Assembly Products Inc.—Various types of panel meters and pyrometers are discussed in an eight-page brochure. Electrical indicating panel meters with clear plastic cases and black bakelite cases are illustrated. Photographs and specifications of indicating and kiln pyrometers are also included. Brochure contains ordering information and price lists of panel meters.

Circle No. 81 on Reply Card

Limit Switches

R. B. Denison Mfg. Co.—File-folder type catalog includes data on contact arrangements, ampere ratings, operating information and electrical characteristics of heavy duty limit switches. Twelve-page catalog also describes numerous mounting plates, levers and covers available with company models. Photograph illustrates interior of the switch and its features.

Circle No. 82 on Reply Card

Electric Check Writers and Signers

Todd Co. Inc.—Five electric check preparing machines are covered in an eight-page bulletin. Among these are the tandem checkwriter which performs the six operations of imprinting and protecting the check sum, listing and adding the amounts for a permanent accounting record, signing the check and counting the checks as they are discharged into a locked vault. Check signers are available with manual or automatic feed for signing up to 5200 checks an hour.

Circle No. 83 on Reply Card

Unitized Pulse Systems

Electronic Instruments Div., Burroughs Corp.—Unitized approach to assembly of pulse test and control systems and the equipment needed to do the job are outlined in a six-page brochure. Pulse control equipment discussed includes pulse generators, delays, flip-flops, mixers and coincidence detectors. Specifications and photographs of different pulse units are included.

Circle No. 84 on Reply Card

Control of Electroplating Rinses

Industrial Instruments Inc. — Solu bridge automatic rinse tank controller is discussed in four-page bulletin. Tank control unit operates by continuous measurement of the electrolytic conductivity of the rinse water. Minimum quantity of clean water for the dilution of chemicals is admitted into the rinse tanks. Bulletin illustrates system for rack and barrel electroplating, and includes photographs of unit in application.

Circle No. 85 on Reply Card

Industrial Counters and Controls

Atomic Instrument Co.—Two data sheets describe a line of unitized modular industrial counters and controls. Two groups of instruments are featured: totalizers or simple counters, and preset counting units. Examples of several counters are shown, and information on specifications and prices is included.

Circle No. 86 on Reply Card

Precision Spindles

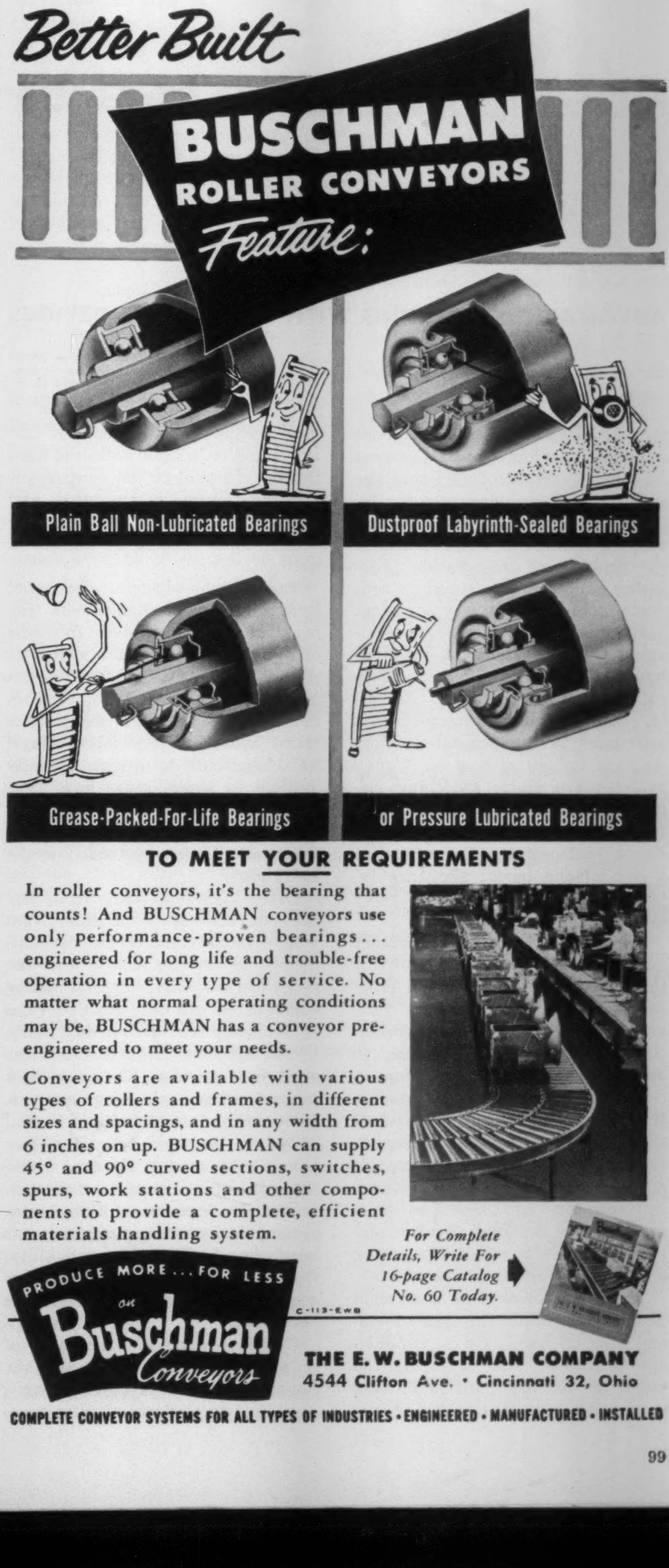
Standard Electrical Tool Co.—Line of precision spindles for grinding, boring, drilling, milling, and routing heads is discussed in new catalog. Details on machine tool attachments including slides, feeds, traverses and tables are included. Catalog features a group of illustrations of custom built spindles for all types of industry.

Circle No. 87 on Reply Card

Electric Tachometers

Electric Tachometer Corp.—Small, electric tachometers designed for production control, speed indicating or checking applications, are described in 20-page bulletin. Illustrated in bulletin are ten magneto types with accessories for connecting magnetos to drive sources through direct couplings, pulleys, chain and sprockets, spur gears or friction drives. Bulletin includes mounting information, dimensions and photographs of electric tachometers.

Circle No. 88 on Reply Card



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AUTOMATION abstracts

AUTOMATIC SWITCHING WITH SOLID-STATE DEVICES

R. A. RAMEY
Westinghouse Electric Corp.
Pittsburgh, Pa.

WHEN PRESENT-DAY industrial relaying systems were analyzed functionally, it was found that the major use of relaying was for information processing rather than power switching. It was found that the problem of information processing could be considered as separate from that of power handling.

Engineering problems in developing Cypak systems at Westinghouse fell within logic science rather than the relay art. Actually, their specific development is analogous to the general development of industrial control. Cypak systems are static switching circuits developed for industrial control applications. They are not direct replacements for relays on a one-for-one basis; they are intended as replacements for relay systems.

The industrial-control designer uses two basic types of information to control machines and processes; a continuous signal of variable quantity or analog information; or a discontinuous signal in discrete amount or digital information. The entire science of industrial control has been built around these two fundamental concepts. Consequently, industrial control components, as well as systems, fall into one of these two categories. For example, the tachometer generator is an analog device; a relay is a digital device.

The application to be controlled usually determines the type of control system used. On a variable-speed planer, for example, the speed of the table during cutting is usually controlled through analog means. At the end of the cut, however, a limit switch is used to send a signal to the control, indicating the end of the cycle, and initiating high-speed return of the table. This control is digital in nature.

The switch—electric, electronic, hydraulic, or mechanical—is the heart of a digital system. In terms of system operation, the switch is simply turned ON and OFF in accordance with the control requirements. And although many electrical switches, especially relays, have been built to operate literally millions of times, users have long asked for a switch with still longer life—one that would virtually never wear out. Cypak systems may be the answer.

Cypak systems come from the area of solid-state physics, from which have come such developments as the transistor and the magnetic amplifier. The one thing common to all solid-state devices is that they have no moving parts. Cypak systems make use of these solid-state devices. They are, in a general sense, switching systems. Hence, they are essentially digital in nature, but can be easily combined with analog devices where the control problem warrants it. In the development of Cypak systems, principal design emphasis has been placed on extreme reliability, flexibility, ultimate utility, and low cost. These design objectives have been met.

Cypak systems are composed of a small number of basic elements, none of which has moving parts, combined to perform specific functions. The functions performed are familiar to engineers working in computer technology or with relay and switching circuits. These functions may be thought of as building blocks that can be combined in a variety of ways to establish a desired relationship between the information that is fed into the control system, and that which is taken out. In the broad field of communications, they are referred to as logic functions.

Operational Functions

The first is called the *AND* function, *Fig.* 1. Here an output is obtained only when all of a given number of input signals are applied. In other words, given inputs *a* and *b* and *c* and . . . *j*, and the *AND* function delivers an output.

Second is the *OR* function, *Fig.* 2, where an output is obtained when any one of a number of inputs is applied. Hence, given any input *a* or *b* or *c* or . . . *j* the *OR* function delivers an output.

Third is the *NOT* function, *Fig.* 3. In this case, an output can be obtained only when no input is applied. Therefore, given an input, *a*, no output is obtained; or given no input, the *NOT* function delivers an output.

Fourth type is the *TIME* function, *Fig.* 4. Actually, there are two types—a limited and unlimited *TIME* function. Limited *TIME* means that, following an input, a specified time passes before an output is obtained. Or in other words, given an input, *a*, and output is obtained from a limited *TIME* function after a specified time, T_1. The unlimited *TIME* function, as the name connotes,

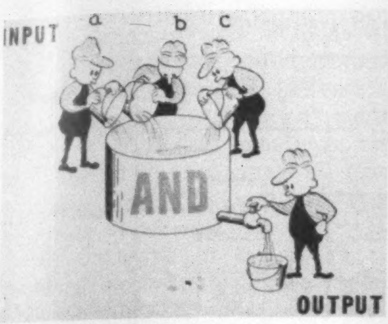

Fig. 1—This cartoon representation of the *AND* element's function indicates that all of a number of inputs must be present before an output can be obtained

will deliver an output following an input until such time as a second input is fed into the system; the second input stops the output. Hence, given input, *a*, the unlimited *TIME* function will deliver an output until input *b* is applied.

Application Example

To give some idea of how these logic functions work in actual circuits, let's investigate a simple application—an automatic liquid level control.

Suppose there are two tanks, *A* and *B*, in which we wish to control the level, *Fig.* 5. Suppose we make the further restriction that only one tank can be filled at a time. The equipment will be: A valve for tank *A* and a valve actuator; one for tank *B* and its actuator; a common supply valve, *C*, and an actuator; level sensing devices for both tanks; and, of course, a control.

If we were to construct a Cypak system for this control, we would find that two *NOT* elements, one *AND* element, and one *OR* element would be required, *Fig.* 6. Because we have imposed the restriction of filling only one tank at a time, the input from the level senser on tank *A* must be fed into a *NOT* element, which controls the valve for tank *A*, and into an *AND* element, which controls the valve for tank *B*. The input from the level senser in tank *B* must be fed to its associated *NOT* element which in turn feeds into the *AND* element controlling the valve for tank *B*. We, of course, want the common valve, *C*, to be open any time either tank is low so the output from both *NOT* elements must be fed into an *OR* element which controls valve *C*.

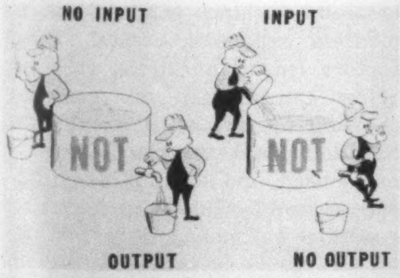

Fig. 3—The *NOT* element will produce an output only when there is no input

When the tanks are full, the *NOT* elements are receiving signals from their corresponding level sensers. Hence, the *NOT* elements will deliver no output and the control will not be actuated. If only tank *B* is low, the *AND* element will receive a signal from the level senser on tank *A* as well as from the *NOT* element for tank *B* and will actuate valve *B* and valve *C* through the *OR* element.

These functions, of course, are not peculiar to Cypak systems. Almost any machine operation or process function can be described in terms of these four functions. Even when an operator is used, his movements can usually be reduced to some combination of these functions. Furthermore, there are a great number of component combinations that will perform these functions—relays, electronic tubes, and many others. However, the field is narrowed by the establishment of several design objectives.

The first objective in the design of Cypak systems was the elimination of all moving mechanical parts to assure longer life, higher reliability, and a high degree of freedom from environmental influence; second objective was availability and reasonable ease of manufacture; and the third objective was cost. The end product had to be produced at a cost equal to or less than existing systems. These objectives have prompted the use of semiconductor and magnetic-core devices for components of Cypak systems.

The *AND* and *OR* functions are conveniently accomplished by semiconductor diode networks. Selenium diodes, and dry-plate units have been perfected for use in magnetic-amplifier circuits. They have proved highly reliable and relatively inexpensive. If environmental conditions preclude the use of selenium diodes—silicon diodes, which are crystalline units—can be used, but at somewhat higher cost.

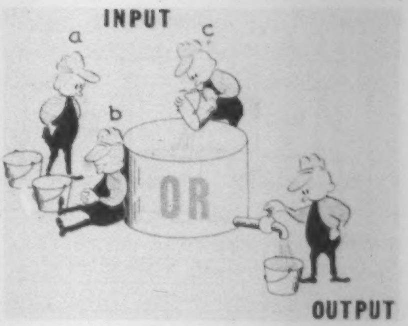

Fig. 2—The *OR* element produces an output when any one of a number of inputs are present

The components to accomplish *NOT* and *TIME* functions are more complex since they require information storage, and amplification. To meet the design objectives, special magnetic amplifiers and transistors with appropriate circuit components have been used. Because there is often a weakening of signal through diode networks, it is desirable to use magnetic or transistor amplifiers to maintain the original signal strength throughout the system.

The principal method employed to maintain comparable cost was the use of very low power levels in the decision-making or logic components of the Cypak system. It is the current thinking that these power levels should be as low

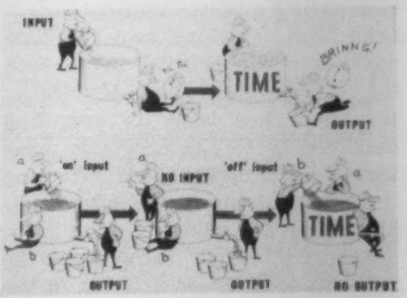

Fig. 4—The limited *TIME* element produces an output a discrete time after an input is received. The unlimited *TIME* element, below, will produce an output for an indefinite time after receiving an input until a second input is received

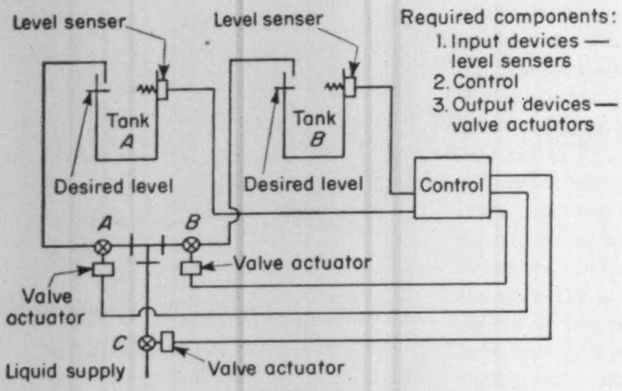

Fig. 5—A schematic of a two tank, liquid level controlled installation

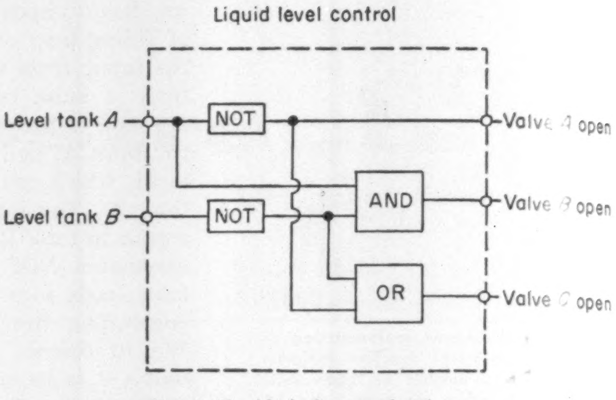

Fig. 6—The block diagram for the control for the liquid level control shown in *Fig. 5*

as 10 milliwatts or even less.

Amplification from the logic to the power level is preferably accomplished by magnetic amplifiers. However, transistor amplifiers may be used, and there may be some cases where, due to the large amount of power to be handled, a standard electromechanical contactor would be desirable. This use of low power level inputs also makes it possible to utilize unique pushbuttons and limit switches that have no moving functional parts or contacts. Photo transistors, for example, can be easily integrated into a Cypak system without intermediate amplification.

Cypak systems can accomplish functions similar to those accomplished by other control systems, but elements and devices that make up the system cannot be interchanged on a one-for-one basis. With the high reliability and performance of the new systems, one can visualize future trends that will result in integrated process and machine operations vastly more complex and extensive than anything now known to industry.

From a paper entitled, "The Theory of Cypak Systems" presented at the Westinghouse Machine Tool Electrification Forum in Buffalo, N. Y., Apr. 1, 1955.

BUY OR LEASE FOR PROFIT

R. A. PERKINS
Kearney & Trecker Corp.
Milwaukee, Wis.

IT IS certainly no startling observation to recognize that American business is face to face with some of the keenest sales competition it has experienced in 15 years. Ultimately, this pressure will compel all industry to survey its manufacturing facilities for the purpose of eliminating obsolete and inefficient equipment. Machine tool facilities constitute the critical nerve center of manufacturing efficiency; yet there has been an appalling indifference to the creeping obsolescence which has been affecting the basic industries which use metalworking equipment.

Industry itself recognizes the problem of obsolescence, but in the past has been faced with a twofold dilemma:

1. Insufficient allowances have been made for depreciation chargeable to operations as they are incurred.
2. Competitive industry has not been able to include equipment replacement costs in its selling prices.

American industry became a world leader because of its ability to mass produce items at a cost which most people could afford. Engineering and manufacturing skills were combined to give us some of the finest productive equipment to be found in the world. Today, after a series of international conflicts which have taken their toll, American industry has taken an inventory in the 16-basic industries—and it doesn't like the results! For example, 56 per cent of the milling and precision boring machines are more than 10-years old. Actually, nearly 20 per cent are more than 20 years old. It has been estimated that machines of a 1950 design average about 40 per cent more production than 1940 models. To express this another way, these older models are costing industry approximately a billion dollars each year through lost production.

The fact that our production equipment is becoming technologically outmoded is not our only problem. Since the 1940's, prices have doubled. This, of course, would make no difference if industry had been allowed to retain twice as many dollars. However, renegotiation, excess profits taxes, and rising costs (in material, labor and fringe benefits) all have made difficult the building of increased working capital, not to mention expansion capital. These factors led to questions such as, "How can I keep my company growing as fast as it should, get the additional working capital I badly need, and still not lose financial control?" This very searching question was asked by a member of the Young President's Organization during a recent survey.

Prior to the inception of machine tool leasing, the customer had a choice of two methods of obtaining equipment; outright purchase or purchasing on the installment plan, i.e., conditional sales contract or chattel mortgage. It was during an era such as this that Kearney & Trecker's tool-lease plan was introduced.

Our objective in setting up a tool-lease program was based upon what we felt were some rather apparent benefits to leasing companies. Working capital can be released for other purposes, and production can be expanded without further debt. In that manner, the company would not be limiting its future borrowing capacity. The tool-lease plan would assure the lessee company of future services of a machine as long as those services were needed, without committing that company for the total life of the machine, and thus avoiding the risk of high obsolescence. A manufacturer would be provided facilities to maintain exceptionally high standards of efficiency and capacity without high investment. Users can make a one-year or longer trial installation of machine equipment when they are not certain which is the most advantageous. In other words, they can judge merit on actual performance in their own shop without assuming the obligation of purchasing the machine.

The opportunity to lease offers a mutual benefit to both the manufacturer and the user in the matter of employing experimental machine models on a production basis. Field testing of machine tools under varied but exacting production requirements is of great assistance to the builder in perfecting his product. The user meanwhile gets the immediate benefit, at a lease cost, without committing himself for an untried, unproven product.

Leasing also offers greater stability of income to a capital equipment maker—a marked advantage in a feast or famine industry. Take the hypothetical case of a manufacturer who has leased enough equipment to bring him a rental income of $100,000 in 1953. His production of new equipment declines 10 per cent, the average for his industry, but his rental income holds at the same level because of the machinery he leased in prior years.

Need to Modernize

The 1954 Internal Revenue Act undoubtedly liberalizes depreciation policies. Under the "declining balance" and "sum-of-the-digits" computations, approximately two-thirds of the cost of a new asset can be recovered in the first half of the estimated useful life. However, the advantages of the new depreciation methods are only pronounced where the assets have a short estimated useful life. An allowance of twice the straight-line rate, where the life is extremely long, will not permit recovery of a substantial amount of the investment over the early years.

More realistic depreciation policies have been a crying need in industry for some time. We in the machine tool industry would be the last to deny this fact. However, how much good will a more real-

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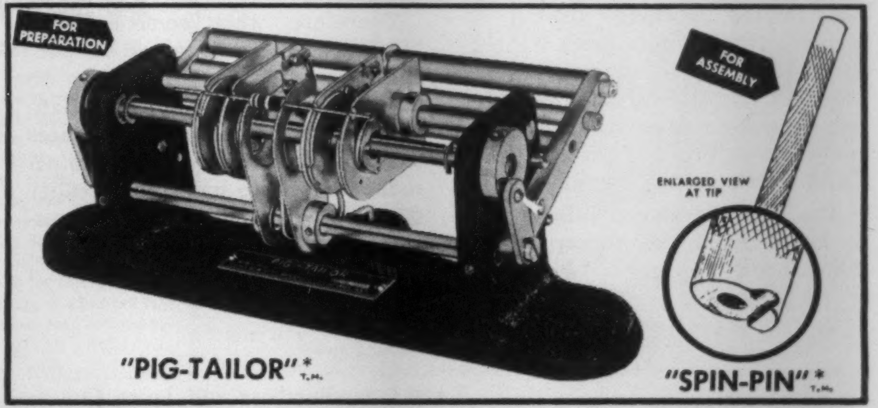

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istic depreciation policy be to a company with limited working capital? A homey illustration might be the case of all of us when we were younger. Our problem wasn't "Shall we buy or shall we lease a home?" It was simply, "Can we pay the rent?" In other words, depreciation presupposes ownership, and ownership presupposes the ability to purchase the necessary equipment. Increased costs, increased taxes, and reduced purchasing power have combined to make replacement of present facilities a nightmare for even large companies. Now that industry has been placed on a pay-as-you-go plan of tax collecting, the working capital problem will be even more vital.

The next logical question which a cost-conscious management asks is, "which is cheaper, the leasing or the purchase of capital equipment?" Exactly what is meant by "cheaper?" Rising labor costs have forced business to recognize the importance of modern-day equipment in its attempts to remain competitive. Even though a machine is in perfect physical condition, it may have become obsolete. Industry is thus faced with the question, not of shall it obtain new equipment, but how it can obtain new equipment. Where a company has limited working capital, it would certainly seem short sighted of that company not to realize profit through rental of new equipment merely because it felt it could realize more profit if the company could purchase the equipment.

The example shown in TABLE 1 is based upon the following assumptions:

1. The 1940 machine was purchased for the sum of $10,000, has a useful life of 20 years, and is being used for the second ten-year period.
2. The 1950 machine was purchased for the sum of $20,000, has a useful life of 20 years, and produces 40 per cent more product than the 1940 machine.
3. The 1950 leased machine presupposes straight rental, no purchase option being exercised.

The foregoing illustration disregards possible labor savings, and was shown to emphasize only these points:

1. There is a limited profit and cost advantage of ownership over lease.
2. There is a tremendous profit advantage in obtaining modern productive equipment (either through purchase or lease) over retaining technically outmoded equipment.

Where a company has available capital, and if the profit to be made on the acquisition of the capital equipment is greater than that which could be realized on the employment of the capital, it should purchase the equipment. If, however, the return on capital is greater than that which could be realized by purchasing an asset, sound business practice would be to lease equipment.

Therefore, when someone asks "Is it better to lease or to purchase?", all the facts must be weighed before an intelligent answer can be given. Thus, this ceases to be a hypothetical problem. It reduces itself to hard, cold reality to be decided solely by the customer.

In closing, let us review for a minute the facts essential to a wise decision. The really important savings are not to be realized through comparisons between the ultimate cost of equipment purchased as compared with equipment leased. The major savings are to be realized by replacing technologically outmoded equipment with modern tools—regardless of how you obtain their use. Outright purchase offers as an inducement the lowest overall cost, but requires the largest immediate cash outlay, and the machine cannot be returned when not needed. Purchase on time payments offers the same cost preference as does outright purchase except for financing charges, but, again, the machine cannot be returned when not needed. Leasing offers the lowest immediate cash requirement and the machine can be returned when not in use, but the lessee acquires no equity in the machine unless he exercises the purchase option rights under his particular lease plan.

It is perfectly obvious that our tool-lease plan was formulated for the express purpose of placing more Kearney & Trecker machines at work in industry. However, it is our feeling that tool-lease has and will continue to have a more far-reaching effect on the economy as a whole, through the infusion of working capital into that economy for its betterment and advancement, thus serving a specific need in a highly competitive industrial world.

From a paper entitled, "Advantages of Leasing Production Equipment" presented at the Annual Meeting of ASTE in Los Angeles, March 1955.

TABLE 1—Purchase and Lease Comparison

Debits and Credits	1940 Machine Purchased	1950 Machine Purchased	1950 Machine Leased
Sales—(10 year period)	$300,000	$420,000	$420,000
Variable costs	150,000	210,000	210,000
Marginal balance	$150,000	$210,000	$210,000
Fixed cost	$100,000	$100,000	$100,000
Depreciation (sum of digits)	2,619	14,763	–0–
Interest on average book value @ 3½%	322	4,144	–0–
Machine rental	–0–	–0–	29,000
	$102,941	$118,907	$129,000
Profit before tax	$ 47,059	$ 91,093	$ 81,000
Book value of machine	–0–	5,237	–0–
Net operating advantage	$ 47,059	$ 96,330	$ 81,000

THE CONTROLLER'S PART IN AUTOMATION

T. F. BRADSHAW
Cresap, McCormick & Paget
New York, N. Y.

MOST SIGNIFICANT change going on in the business world today is the management revolution. The core of this large change in ways of managing is the substitution of management by plan for management by reaction to events. This new way of management consists of three parts: (1) Adopting the concept of management planning and control, that is, the setting up of company and departmental goals; (2) organizing so as to push the profit motive as far down the organization as possible, and (3) building an organization which can help the chief executive carry out his job of co-ordinating the parts, and which can supply him with the tools of management planning and control.

One thing has been added in recent years. A mechanical revolution in data processing has occurred which will, I believe, alter substantially the rate at which this new concept of management will evolve. It will do so by providing tools of forward planning and controlling operations with a speed, economy and completeness that none of us thought possible only a few years ago. I am convinced that the only way that the enormous savings potential inherent in the use of electronic data processing equipment can be realized fully is by applying these machines within the framework of this new concept of managing.

Effective utilization of electronic equipment demands a new concept of procedures which, in turn, will supply the tools, by which management can plan and control operations. Electronic equipment and this new concept of management techniques and procedures will provide the tools of planning, testing plans, co-ordinating the various parts of a plan and following actual results compared to a plan. These are the functions reserved for top management in any decentralized operation.

Proper use of these tools will, in my opinion, provide the means of making decentralized management effective. Divisional managers will be provided with overall plans, and their areas of responsibility will be clearly marked. They will be provided with reports which will enable them to control their operations within the limitations of the plan. Only with a concept such as this can we attain real decentralized management — that is, profit decision-making at many locations throughout the organization, but all decisions geared to attaining the overall objectives of the company.

The trend to divisional controllership has been the natural accompaniment of the trend toward decentralized management. When a man is given profit responsibility, he must be given the tools necessary to make profits. One of these tools, of course, is adequate data analysis and interpretation service. The trend to central machine ac-

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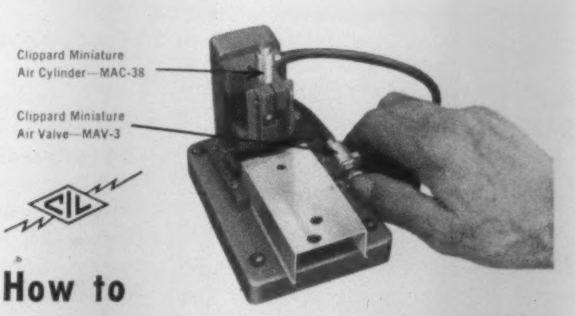

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counting sections has been forced by the necessity of grouping sufficiently large units of punched card equipment together in order to achieve the benefits of factory type operations. The trend toward separating data processing from data analysis has stemmed from the realization that the two are different functions requiring different approaches, different methods, different kinds of men. This separation has taken the form of creating two distinct departments up and down the line in the accounting organization; or it has taken the form of setting up a data analyses group outside of the accounting organization and letting the latter process the data. Whatever the form, the trend has been unmistakable.

What impact will the advent of an integrated electronic data processing system have on these organizational developments? Certainly the use of electronic data processing, taken together with improved communication devices, will require a greater degree of centralized data processing than is now the case. The equipment will require highly specialized personnel to program the procedures and run the machines. This specialization of personnel will widen the breach which already exists between those who process data and those who design reports and interpret results.

Finally, the divisional controller concept will be strengthened, if we accept the definition of a controller as one who analyses and interprets, rather than one who records and processes data. Wherever there is profit responsibility, there must be strong controllership in this sense.

In brief, then, once we have accepted integrated electronic data processing, organization of the data processing and analyzing function will take this form:

At the top level of management, a data processing center into which is fed original data and from which is obtained reports and documents for all levels of management, plus an analytical group whose function it is to help management plan and control operations by devising control systems, analyzing results and translating business problems into computer language.

At the divisional level of management, an office manager whose function it is to prepare original data for transmittal to the data processing center, plus an analytical group whose function it is to analyze and interpret reports prepared by the data processing center and to insure that the informational needs of the division are being met.

A large revolution in concepts of management is now under way. The advent of electronic equipment has added impetus and force to this revolution; it has not changed in direction. Many controllers have been vitally concerned with this changing management concept; many have nurtured and fostered it. These are the controllers who now are—and will continue to be—top management's indispensable figure partners. Their farsightedness will be reflected in their companies' financial statements.

From an address entitled, "New Horizons in Management Planning and Control through Data Processing" delivered at the Midwestern Regional Conference of the Controllers Institute of America in Minneapolis, Minn., June, 1955.

AUTOMATION BRINGS SOCIAL CHANGES

J. B. SHALLENBERGER
Stanford Research Institute
Stanford, Calif.

AUTOMATION in its earlest days was a frightening prospect to the uninitiated. We are always frightened by things we do not understand. The best news is that automation has now progressed far enough that we can at last understand it. Even the general public is becoming better acquainted with it and thus, less frightened of its implications and more impressed with its ultimate social benefits.

But social workers cannot rest easily on the hope of full and stable employment. Automation will in some respects reconstitute our worker, changing both his functions, his qualifications, and his mode of life. It will demand of him some fortunate yet troublesome social readjustments.

Let us consider the probable social effects of automation. I shall try to predict some of the effects, leaving to your judgment which of them present readjustment problems, and which of the readjustment problems are within your province to solve.

Increased leisure — the worker has, over the decades of industrial advance, taken his reward for increased productivity in two principal forms, about 40% in increased leisure time and about 60% in more goods and services. More leisure is our good fortune. If idleness creates problems, we must know what to do about them.

Upgrading of skills and virtual reconstitution of the work force—machines learn first to do the repetitive tasks done by semiskilled and unskilled workers, and these workers are the first to be replaced, or trained and upgraded to perform higher skills. There will be a growing demand for machine operators, machine programmers, machine builders, machine installers, machine-information processors, and machine repairmen—all these with higher skills than before. In the offices we shall need educated people for new type jobs as machine designers, draftmen, systems engineers, mathematicians, and logicians. Who will educate these people? How will they adapt to new levels of responsibility?

Reduced demand for the unskilled and untrainable—what can we do with the unskilled workers who do not want to be upgraded and aren't needed in great quantity for low-grade tasks? What can we do with workers who are too old to learn and adapt?

Dispersion of industrial plants—the new automatized factories will be less dependent on large pools of labor and thus less oriented toward heavily populated areas and more toward raw material markets, transportation, and low cost space. Automation lends itself to horizontal production lines. Incidentally, plants that turn to full-scale automation may do their major production on the night shift and reserve large parts of the day for maintenance, repair, and set-up.

Upgrading of communities—decentralization of industrial complexes coupled with a shifting center of gravity of our work force toward the more highly skilled middle class will have noticeable effects on our communities. Growth of industrial urban areas will be curtailed, but communities will continue to grow with the increasing volume of financial, trade, and service transactions. The increasing proportion of skilled middle class residents and the dispersion of industry will gradually combine to increase the attractiveness of our communities and shift the demands for types of recreation and other community facilities.

High price of services—prices of things will go down; prices of services will go up, machines will increase the productivity of factory and office workers and thus their return for their effort, but what about the fellow whose skill cannot be, or is at least not yet, automatized, like lawyers, teachers, engineers, reporters, salesmen, cooks, hairdressers, interior decorators, and many others? These service occupations account for one-fourth of total employment, and such workers will have difficulty increasing their productivity per unit of time or unit of effort. Will society understand why they want higher pay to keep pace with factory and office workers?

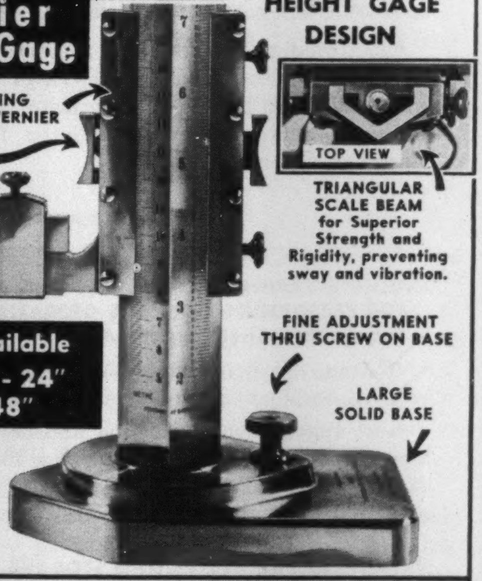
Reduced employee density within factories—as factories level off to horizontal assembly lines and spread less people among more machines, the number of workers per unit of area will be reduced. Instead of overcrowding, some industries will be characterized by widely scattered hermit employees who have to go hundreds of yards to meet coworkers for lunch or coffee break conversation.

Rising standard of living and material abundance—we shall all be better off materially, particularly in the United States where automation will go farthest and fastest. This great good fortune will bring problems, perhaps deeply hidden behind the silver lining, problems of mental growth and conditioning, and need for deeper understanding of our goals at home, even greater problems abroad if through automation we open the gap between ourselves and the have-nots.

The results will vary around the world (for reasons it would take much time to explain), but of this I am certain: Automation will bring more material good fortune to lives everywhere, good fortune in many forms.

It will also bring a growing need for the thinking and inspiration of which social workers are capable, of a search for true values and deep spiritual understanding—so that society may be truly blessed and not burdened with its newfound material resource.

From a talk entitled, "Automation at the Halfway Point" presented at the National Conference of Social Work in San Francisco, June 1955.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SEE PAGE 97

AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

METHOD AND MEANS FOR CONTROLLING AN APPARATUS

Record member such as a card has data-representing marks of different inactive materials. Energy levels of the different materials can be selectively raised so that the chosen marks will control an apparatus. Patent 2,704,634 by Konrad Rauch, assigned to the National Cash Register Co.

◆ ◆ ◆

Handling

PNEUMATIC TURNOVER FOR GLASS MOLD CARRIERS

Carriers are turned over and also righted by application of pneumatic pressure to proper side of operating arm moving in arcuate cavity. Patent 2,701,448 by Charles A. E. Johnson, assigned to Lynch Corp.

MAGNETIC CAN THROWOUT MECHANISM

Electromagnetic element removes slack filled metal containers from line of travel in accordance with indication from detecting head. Patent 2,700,465 by William Pechy and Victor T. Grover, assigned to American Can Co.

◆ ◆ ◆

Machines

MACHINE HAVING ORBITALLY MOVING DIES FOR PERFORMING CONTACT OPERATIONS ON MOVING SHEET MATERIAL

Contact operations are performed on sheet material continuously fed between dies moving into and out of engagement with one another due to rotation of their drive and support members in orbital paths. Patent 2,704,577 by Bruce M. Haldeman, assigned to Manhasset Machine Corp.

APPARATUS FOR ASSEMBLING STORAGE BATTERY ELEMENTS

Mechanized suction head moves parts to be assembled from supply stack to assembling station. Patent 2,704,593 by Charles D. Galloway, assigned to the Electric Storage Battery Co.

Measuring

HIGH SPEED CHECK WEIGHER

Articles continuously moving on a special conveyor section are weighed and offweight articles are moved off conveyor by rejecting members. Patent 2,701,639 by James C. Petrea, assigned to Wright Machinery Co.

TEMPERATURE CONTROL FOR BILLET HEATING APPARATUS

Temperature is sensed by a thermocouple having a sharply pointed end adapted to be driven beneath the surface scale of a billet by a power means. Patent 2,703,495 by William E. Benninghoff, assigned to the Ohio Crankshaft Co.

AUTOMATIC MACHINES SUCH AS CIGARETTE MAKING MACHINES OR THE LIKE

Density of tobacco particles in a cigarette core is measured while in motion by use of radiation sources and ionization chambers. A current is obtained related to variation of density from a set standard. Patent 2,704,079 by Desmond W. Molins and Gordon F. W. Powell, assigned to Molins Machine Co. Ltd., London, England.

◆ ◆ ◆

Packaging

APPARATUS FOR APPLYING LINING SHEETS TO CRATES

Apparatus positions crossed overlapped strips of metal foil as a lining within a crate and also folds the foil over the top edges of the crate. Patent 2,704,013 by Julian L. Reynolds and Hugh C. Lawson, assigned to Reynolds Metals Co.

ARTICLE ORIENTING MACHINE

Device receives tubular articles having opposed faces of unequal size with either face uppermost and by means of a turning plate orients all with same face up. Patent 2,701,637 by John W. Rundt, assigned to The Timken Roller Bearing Co.

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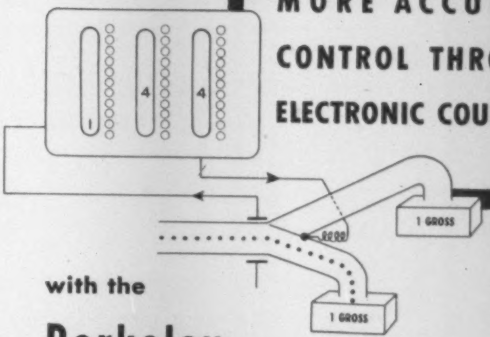
Process

MOLDING PROCEDURE

Plastic sheet is prepared from a mixture of sand and an incompletely cured thermosetting resin. The sheet is then shaped over a die and heated until it develops mechanical strength to be used as a mold for making a metal casting. Patent 2,705,822 by Gosta Vennerholm, assigned to Ford Motor Co.

APPARATUS FOR PRODUCING DISCONTINUOUS CONDUCTORS

Apparatus to automatically produce a series of successive predetermined lengths of conducting material on a continuous length of insulating core passes a fusing current through a short section of a continuous length of the conducting material at predetermined intervals along its length. Patent 2,706,231 by Alfred W. Tyler and Chapin Wallour, assigned to the United States of America.



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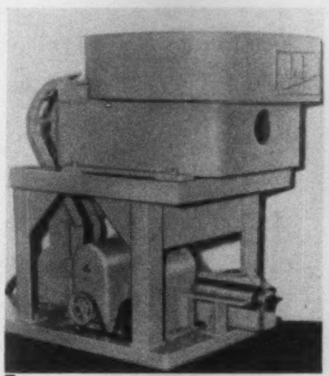

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